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Generation of Architectural Form: Standardization and Adaptation

Sungmo Park
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Sungmo Park entitled "Generation of Architectural Form: Standardization and Adaptation." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Architecture, with a major in Architecture.

Scott Wall, Major Professor

We have read this thesis and recommend its acceptance:

Jon Coddington, Edgar Stach

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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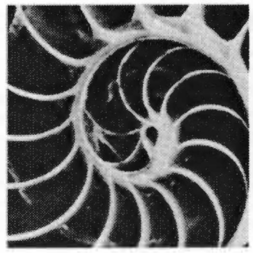

A Thesis
Presented for the
Master of Architecture Degree
The University of Tennessee, Knoxville

Sungmo Park

August 2004

Dedication

This thesis is dedicated to my wife Youjin Choi and my son Brian Park, who have endured hardship and frustration over my course of study, all the while offering encouragement and remaining inspirational. This thesis is also dedicated to my parents, Youngun Park and Youngsook Koo and my brother, Jaeyoung Park and my sisiter, Soyoung Park.

Acknowledgments

Thank you to all of the professors that have helped me over the course of the last three years. Also, I appreciate the stimulation, support and friendship of those who have endured through the process concurrently. I would like to thank my committee: Scott Wall, Jon Coddington, and Edgar Stach, for their ideas, and valuable guidance through the thesis process. I would also like to thank my classmates whose encouragement and insights made this thesis investigation deeper and more rewarding.

Abstract

"The form of an object is a diagram of forces; in this sense, at least, that from it we can judge or deduce the forces that are acting or have acted upon it; in this strict and particular sense, it is a diagram." – D'Arcy Wentworth Thompson, *On Growth and Form*

Throughout architectural history, architects have made efforts to develop a diversity and efficiency of form to adapt to the natural environment. A prominent issue that has developed from this is what are the factors that have influenced and become form generators?

D'Arcy Wentworth Thompson, in *On Growth and Form*, describes how nature creates a great diversity of forms from an inventory of basic elements. According to Thompson, every creature is formed in accordance with a response to the actions of natural force. "In short, the form of an object is a diagram of force."[1] In other words, the formative processes in natural structures are normally governed by 'least-energy' responses such as honeycomb structure and poppy seed surface. The premise that form is a diagram of force can also be applied to architectural form and structure.

In architectural terms, a force may be considered as any factor which may affect any given form. Peter Pearce, in *Structure in Nature is a Strategy for Design,* points out that there are two forces, intrinsic forces and extrinsic forces which act on the making of form. He claims that intrinsic forces are those governing factors which are inherent in any particular system. Conversely, extrinsic forces are those governing influences which are external to any particular architectural system. He further maintains that "All forms in nature are determined

[1] Thompson, D'Arcy Wentworth, *On growth and form.* Cambridge, Eng.: University Press, 1961. p.16

by the interaction of intrinsic with extrinsic forces."[2] Therefore, architectural form also should be expressed to the reciprocal action of intrinsic force and extrinsic force.

This thesis raises issues regarding standardization and adaptation in the making of architectural form. In the context, standardization is mainly related to intrinsic forces in that standardization makes systems which are efficient in their use of natural material and energy resources. Adaptation is mainly connected with extrinsic forces to allow the diversity of form to develop in accordance with the built environment. Therefore, through the standardization and adaptation, architectural form should be accomplished the state of the equilibrium. In this thesis, I am exploring a new methodology of the generation of architectural form based on the process of standardization and adaptation.

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[2] Pearce, Peter. *Structure in nature is a strategy for design.* Cambridge: MIT Press, 1978. p.xv

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1. Form in Nature

The plant grows from its seed.
The characteristics of its form lie concealed in the potential power of the seed. The soil gives it strength to grow. And outer influences decide its shape in the environment.

- Eliel Saarinen, *The Search for Form*

Before beginning an analysis of the form in nature, one must define the term "FORM". "FORM" has many meanings, such as shape, configuration, structure, pattern, appearance, manner, method, organization, system of relation and so on. However, the word "FORM" in this context will refer to the geometric shapes of objects, the arrangement in space of groups of objects, and the arrangement in space of each of their component parts.

C.H. Waddington, in his essay *The Character of Biological Form,* maintains that form in nature results when a diversity of forces acts in concert. According to Waddington, the wholeness of the form is the effect of the balance of these forces. The forms of natural creatures have some quality of equilibrium. He further claims that "The internal tensions are balanced against one another into a stable configuration, since the configuration is destined slowly to change as development proceeds." [1]

D'Arcy Thompson, in his *On Growth and Form*, illustrates the fragment of bone from a vulture's wing (fig 1) as an example of how the interplay between an organism and its environment result in a form that is best suited to that organism's particular survival. He compares the bone structure of the wing of the vulture with a Warren's truss (fig 2) which is a

[1] Whyte, Lancelot Law. *Aspects of Form.* New York: American Elsevier Publishing Company, 1968. p.46

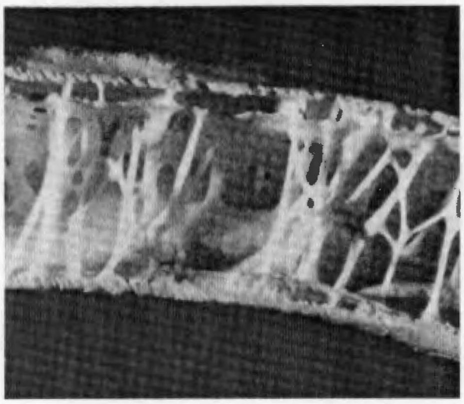

Fig1 Bone from a vulture's wing
Source: Thompson

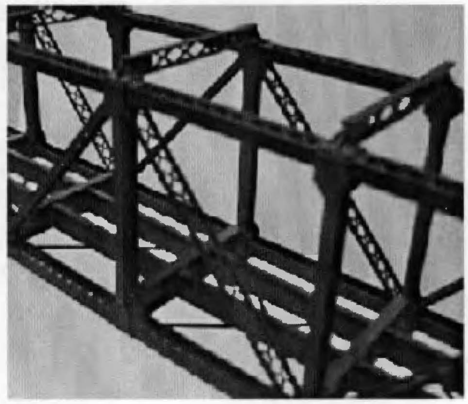

Fig2 Warren's truss
Source: Macdonald

well-known architectural engineering structure. The structure of the wing and the structure of the Warren's truss which require maximum strength with minimum weight are most beautiful three-dimensional lattices.

Andreas Feininger, in his *Anatomy of Nature,* introduces another kind of responsiveness in the structural form in nature. He suggests that through the simple honey comb (fig 3) structure of bees uses little material for construction; it provides more space and strength for storing honey.[2] The honey comb structure is an example of the principle of closest packing.[*] Closest packing is a structural array of natural geometric stability that finds expression in the two and three dimensional arrangements. Like the honey comb structure,

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[*] The aggregation of identical spheres about a nucleus involving 12 spheres in contact with a central sphere (the nucleus) so that each sphere touches four neighbors in addition to the central sphere. In this arrangement, six spheres surround the central sphere, with three spheres lying in the interstices above and three spheres below. The spheres are grouped in three layers. If the three spheres in the top and bottom layers are oppositely oriented, the spheres are said to be cubically close-packed. If the three spheres in the top and bottom layers are oriented similarly so that a sphere in the bottom layer lies directly beneath a sphere in the top layer, the spheres are said to be hexagonally close-packed.

[2] Feininger, Andreas. *The Anatomy of Nature.* London: Thomas yoseloff, Ltd., 1956.

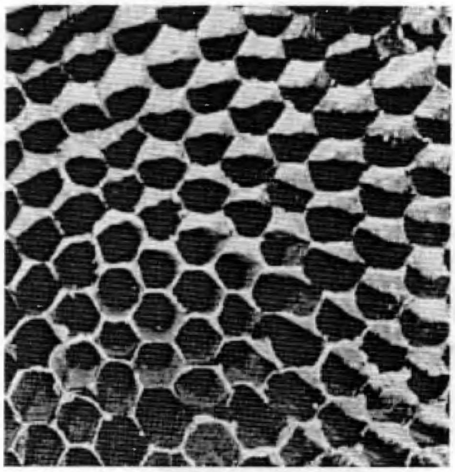


Fig3 Honey Comb Source: Feininger

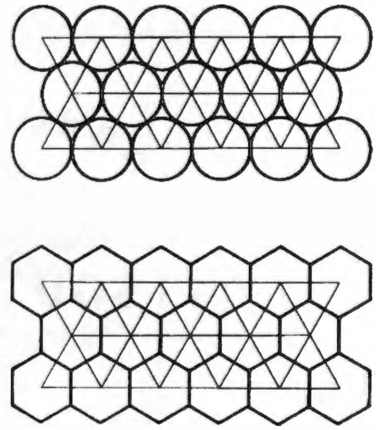


Fig4 Closest Packing Source: Pearce

circles or hexagons are tightly packed and equilateral triangles are formed. (fig4) It can be readily seen that the principle of closest packing is equivalent to that of triangulation, and it is well known that triangulated frameworks exhibit inherent geometric stability.

Alexander Graham Bell demonstrated a new tetrahedron structural system based on the principle of closest packing. (fig5) The intention of this invention was to make very large kites to carry a man into the air. Further, he applied his structural system to building purposes, to create much simpler, lighter and stronger edifices than produced by conventional structural systems. This new system had an influence on other architects, such as Buckminster Fuller and Konrad Wachsmann. Fuller's geodesic dome (fig6) and Wachsmann's roof structure of U.S. Air Force hangars (fig7) are well-known projects.

Moshe Safdie, in his *Form and Purpose,* also claims that every form in nature is able to grow, to change, and to adapt. He points out that as a nautilus (fig 8) grows, it adds additional chambers to its "house" while maintaining its overall proportion of body to shell.[3]

[3] Safdie, Moshe. *Form and Purpose.* Boston: Houghton Mifflin Company, 1982. p.5

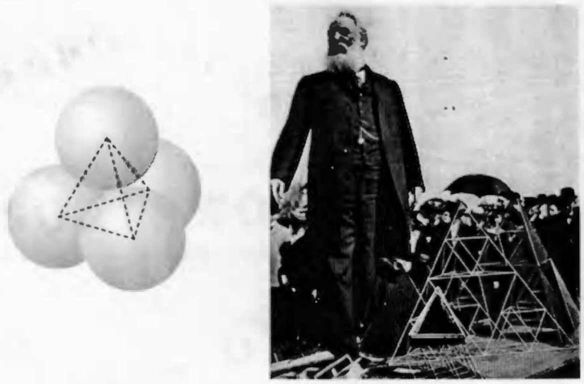


Fig5 Closest packing and Tetrahedron Structure Source : Pearce

Fig6 Geodesic dome
Source: Fuller

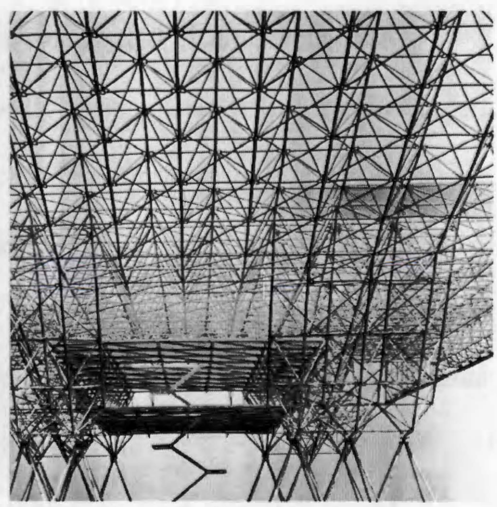
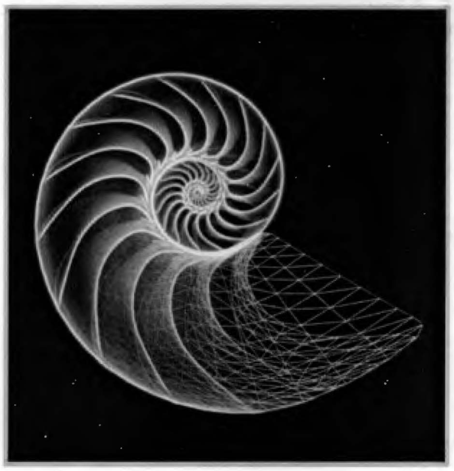


Fig7 Roof structure of U.S. Air Force
Source: Wachsmann



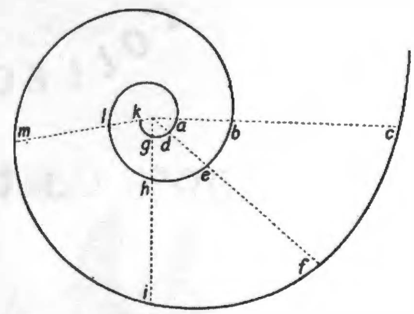


Fig8 Growth of Nautilus
Source: Safdie

Fig9 Spiral of the Nautilus
Source: Thompson

What is more, the nautilus uses the previous rooms for buoyancy so that it may float at different levels in the sea.

D'Arcy Thompson illustrates how the growth of the nautilus pattern results in the equiangular or logarithmic spiral. He claims that a nautilus grows successive and continuous increments; each consecutive phase of growth remains as an integral and unvarying proportion of the growing structure.[4] The shapes of shells have been the issue of many studies which show that their harmonious shapes unfold in logarithmic spirals characterized by the golden section's proportion that is to say as 1: 0.618….. (fig 9) Also, shells are architectural structures which transfer loads by compression, by shear, or by bending tangentially to their surface. (fig 10)

[4] Thompson, D'Arcy Wentworth, *On growth and form.* Cambridge, Eng.: University Press, 1961. p.750

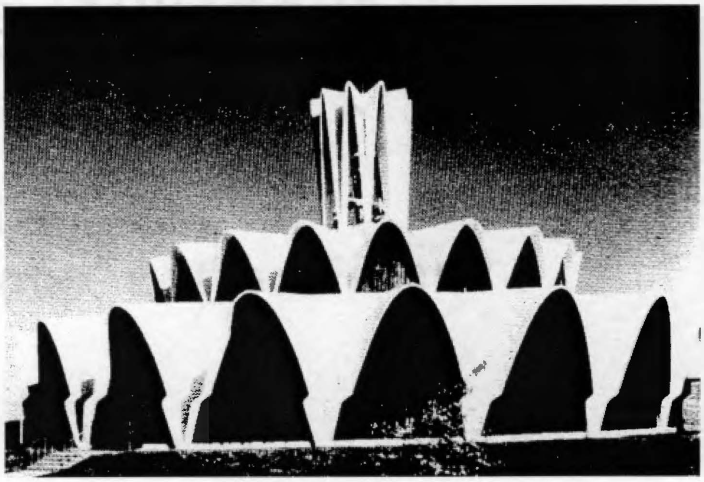


Fig10 Shell Structure Source: Zannos

Another famous shell structure is the Sydney opera house. Because of the complicated shape of initial design, it took more than 10 years to complete. A major problem was that the shapes didn't seem to fit a consistent pattern making prefabrication costly and time consuming. The solution of this project is to use the shells which are taken from the same sphere. (fig 11)

F.G.Gregory, in his essay *Form in Plants*, points out that temperature and the availability of moisture and light have the greatest influence on the forms of plants.[5] Plants adapted for existence in arid regions such as the desert show amazing adaptation in form - the leaves may be so much reduced that the blade is represented only as a woody midrib and appears as a thorn, so well seen in the cactus. Cactus (fig 12) has also remarkable skin structure which is easily found in standardized architectural material that is corrugated sheet.(fig 13) This material is still an economical solution for roofing and wall cladding as it is available in long lengths and provides easy installation.

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[5] Whyte, Lancelot Law, ed. *Aspects of Form.* New York: American Elsevier Publishing company, 1968. p.62

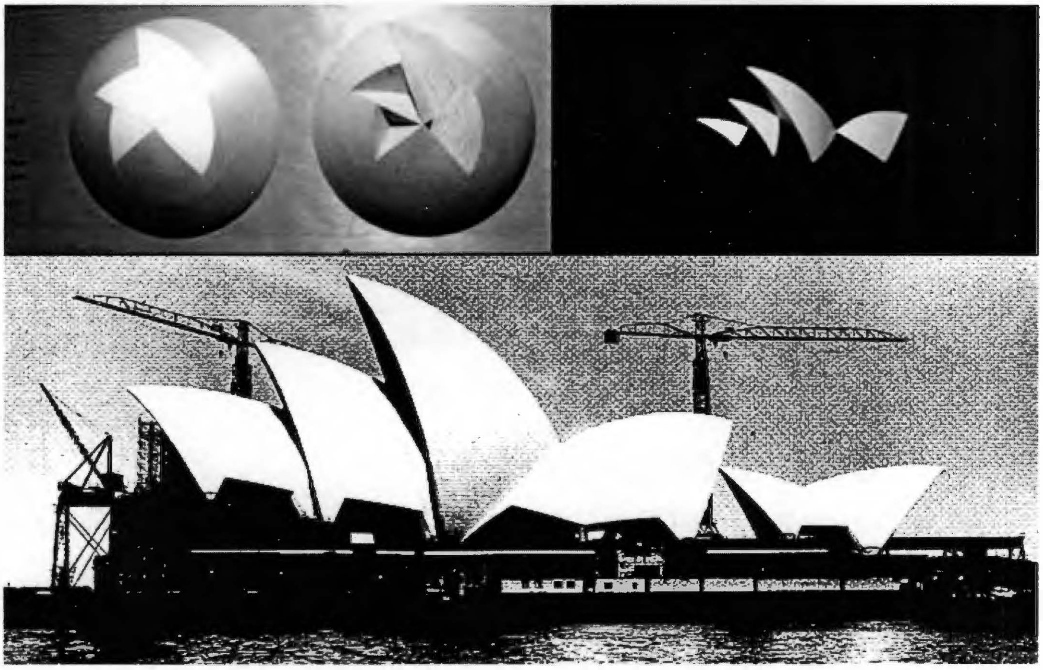

Fig 11 Shell Structure in Opera House Source: Rice

Fig 12 Corrugated Skin, Cactus

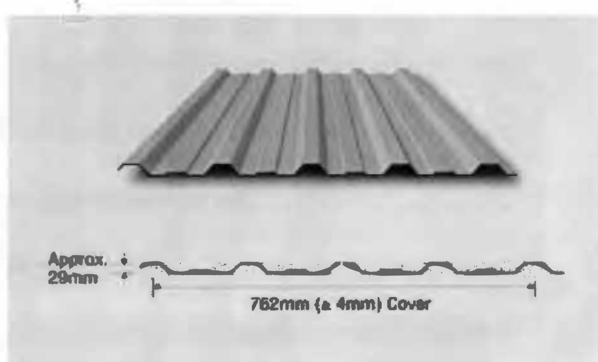

Fig 13 Corrugated sheet

Fig 14 Corrugated form of dune

William Zuk and Roger H. Clark, in *Kinetic Architecture*, illustrate how nonliving creatures form to respond to their environment. According to them, natural form is constantly responding to the forces which act on it and to those which are inherent within it. He also points out that the potential of corrugated form of dune (fig 14) in dessert which is the result of the direct action of wind. As the winds change and blow, the sand dune is transformed until it has met and is in equilibrium with new environmental conditions. [6]

D'Arcy Thompson illustrates that the poppy seed (fig 15) shows a unique dimpled surface which consists of raised edges. Such a pattern is formed by the collapse of the smooth outer shell upon an inner shell due to a loss of moisture. When the outer shell contracts, its surface area remains unchanged and consequently ridges are formed to take up the excess surface area. If a flexible membrane which is only capable of supporting tension is stressed by means of negative pressure then the surface of the membrane becomes concave like the poppy seed skin. Conversely, the membrane is stressed by the

[6] Zuk, William and Clark, H Roger. *Kinetic Architecture*. New York: Van Nostrand Reinhold, 1970. p.5

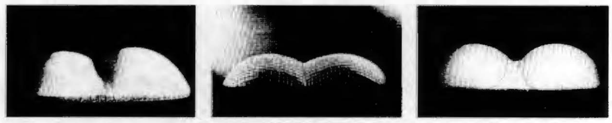

Fig 15 Poppy seed Skin

Source: Pearce

Fig 16(Above) Pneumatic structure Source: Herzog

Fig 17 (Below) Tent roof structure Source: Herzog

differential pressure of gas then a pneumatic form arises. It is deformed in the direction of the less dense agent until its surface is stable in both position and form. Recently, some eminent structural designers such as Frei Otto and Horst Berger have introduced pneumatic structure and tent roof structure using membranes. (fig 16, 17)

Gernot Minke, in 1971, designed the experimental exhibition hall with a single membrane negative pressure system. (fig18) However, the problem is that this structure would not be stable against wind suction and wind pressure without pneumatic stabilization.

It can thus be seen that every natural form, living and non-living, has its own unique form which is indispensable to its existence and changes in response to its environment. Each adaptation, one may observe, resolves itself to create a harmonic relationship with the internal and external forces which shape it. Through this process particularly the latter process, a harmony or stasis with the larger environment is achieved, however temporal that might be.

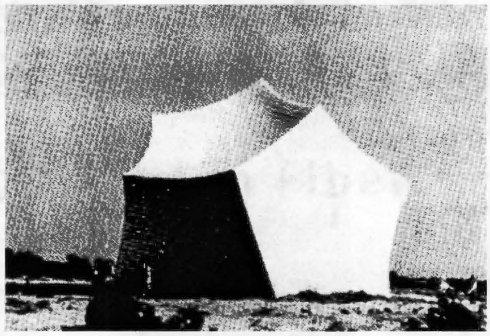

Fig 18 Single membrane negative pressure system

Source: Herzog

2. Architectural Issues; Form in Architecture and Standardization and Adaptation

"We know that all living systems exhibit adaptive behavior. That is, they possess an ability to react to their environments (broadly defined as the set of all objects and events containing a system that changes or are changed by the system's behavior) in such a way that is favorable, in some sense, to the continued operation of the system. A self-organizing system maintains its existence through a continual interaction with its environment. Changes within the system or in the larger world invoke an automatic response aimed at restoring a favorable balance, or homeostasis, between internal and external conditions. In a living system, this point of equilibrium will change as the organization of the system evolves. The very act of evolving entails irreversible changes in the system and its environment. These changes must in turn be accounted for if the system is to survive. The process is cyclic; the living system progresses ever further from an original condition." – Chris Abel, *Evolutionary Planning*

Throughout architectural history, the most prevalent issue has been the origin of form and its relationship to architectural intention; how form is generated, what influences its shape, from what is it derived? There have been many attempts to describe the sources of architectural form.

Mark Gelernter, in *Source of Architectural Form*, explores those questions with five theories of form:

- *Architectural form is shaped by its intended function.*
- *Architectural form is generated within the creative imagination.*
- *Architectural form is shaped by the prevailing Spirit of the Age.*
- *Architectural form is determined by the prevailing social and economic conditions.*

- *Architectural form derives from timeless principles of form that transcend particular designers, cultures and climates.*[7]

He, however, claims that none of these theories are able to give a complete and convincing account of the source of design ideas.

Angus J. Macdonald, in *Structure and Architecture*, claims a different set of considerations of the development of architectural form. According to him, throughout architectural history, structural systems have wholly or partly influenced the making of architectural form.[8] He points out that the Parthenon (fig 19) in Athens is the most

Fig19 The Parthenon Source: Macdonald

[7] Gelernter, Mark. *Sources of architectural form.* Manchester; New York: Manchester University Press, 1995. p 3-17

[8] Macdonald, J. Angus. *Structure and Architecture.* Oxford: Butterworth-Heinemann Ltd, 1994. p.70

famous architecture affected by structure. The Parthenon is as example of using the post-and-beam arrangement (horizontal elements are supported on vertical columns or walls) which is the most common structure in the world of architecture. No attempt was made to cover the structural system and, thus, in the Parthenon the structure and the architectural expression are perfectly united.

Based on Schopenhauer's theory of statics, Alexander Zannos, in *Form and Structure in Architecture*, emphasizes that the architectural form should be reflected in the interaction of intrinsic force and extrinsic force. As he quotes:

> "Form must express the struggle of forces to achieve equilibrium; every architecture member must carry its loads; and the relation of the members to the whole must be such that if one member were removed, we would be left with the impression that the entire architectural work would crumble."[9]

There are a wide varieties of forces that have an effect on architectural form: intrinsic forces and extrinsic forces. Intrinsic forces are those governing factors which are inherent in any particular architectural system. For instance, structural efficiency relative to use of materials and the program or function of the building could be intrinsic forces. Conversely, extrinsic forces are those main influences which are external to any particular building form; environmental condition; natural forces such as the sun, water, heat, and cold; topographical conditions; geological conditions; or building function including the change of its use over time.

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[9] Zannos, Alexander. *Form and structure in architecture.* New York: Van Nostrand Reinhold, 1987. p.102

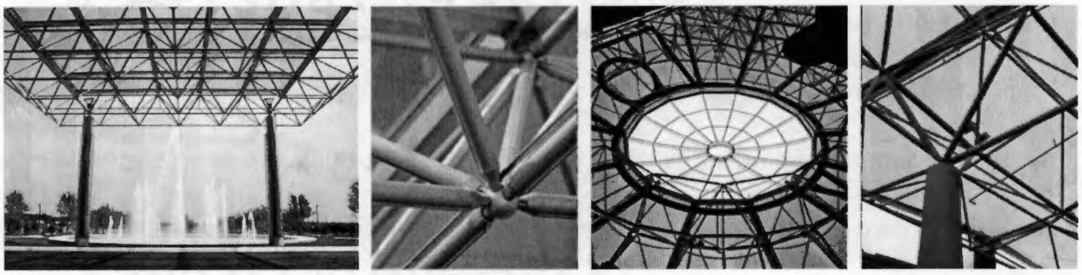

Fig 20 The MERO system Source:

In architectural terms, standardization is related to intrinsic forces in that standardization makes systems which are efficient in their use of natural material and energy resources. The MERO system (fig 20) is one of the first space grid systems and it was introduced in the 1940s in Germany by Dr.Max Mengeringhausen. It consists of prefabricated steel tubes, which are screwed into forged steel connectors, the so-called MERO ball. To this day it remains one of the most popular in use.

The Occidental Chemical Center (fig21) in Niagara Falls, New York was the first building in North America to be constructed with a Double-Skin Façade. Because of the 1970s Oil crisis, Hooker Chemicals & Plastics Corporation wanted to design an energy efficient building. Completed in 1980, it has become one of the oldest examples of the "modern" Double-Skin building. The building envelope is comprised of two layers of green-tinted insulating glass that allow for 80% solar penetration as the exterior skin, a 1200mm air space containing hollow metal, air-foil shaped, white louvers with service grilles and one layer of clear glass as the interior skin; to be a economical building, all the components of the façade were standardized and mass produced.

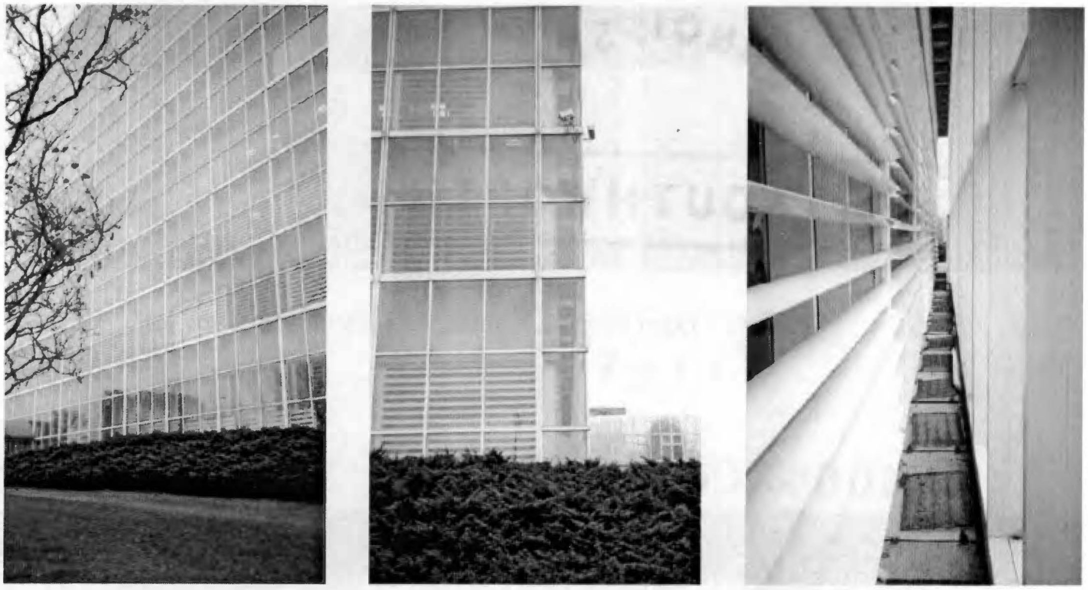

Fig 21 Double-Skin Façade Source:

In March 2001, the Eden Project, (fig 22) a massive environmental center in Cornwall, England, opened to the general public. The finished structure is an unprecedented accomplishment -- a giant, multi-domed greenhouse, containing plants from around the globe. In this project, many flat panels, formed into triangles, pentagons, hexagons or other polygons, are pieced together to form a curved surface. (fig 23) This design is amazing because none of the individual elements are curved at all, but they come together to generate a rounded form that is inspired by Buckminster Fuller's geodesic dome. What is more, one advantage of the geodesic dome shape is that it adapts easily to most ground surfaces. Eden's designers describe the domes as giant bubbles that can be set down just about anywhere.

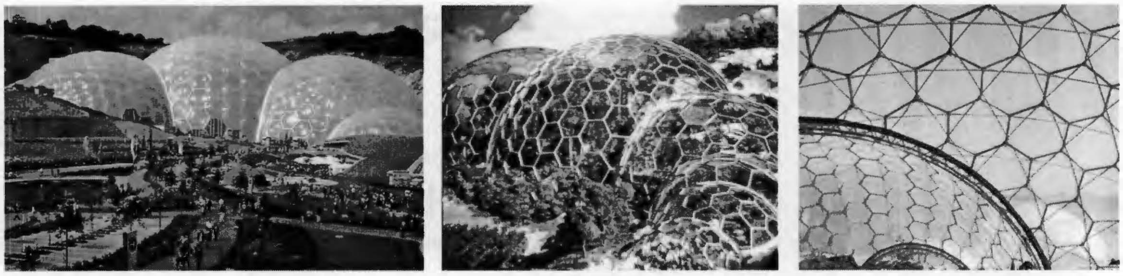

Fig22 The Eden Project Source: Architectural Record

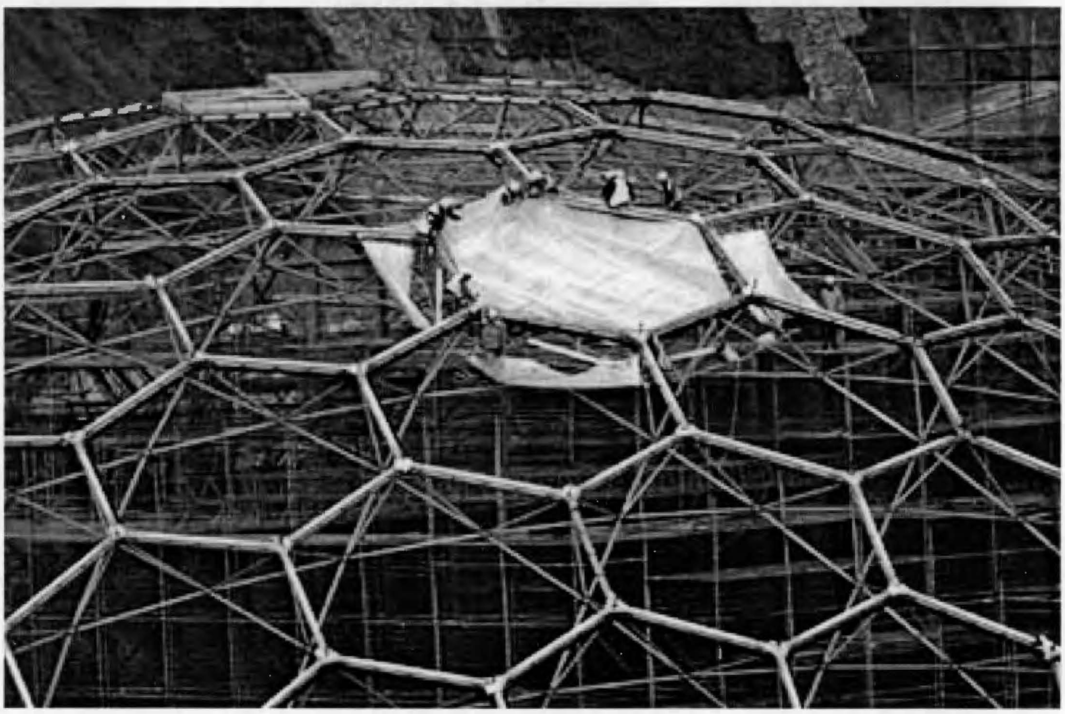

Fig23 Eden Project Standardized Structure Source: Architectural Record

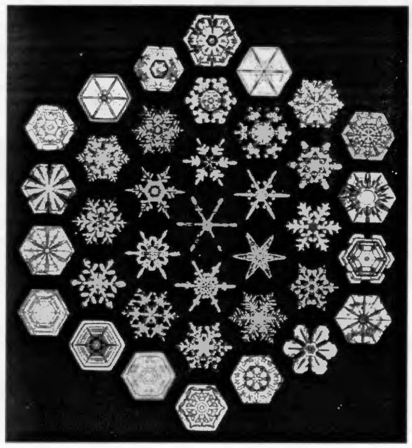

Fig24 Snowflakes Source: Pearce

In architectural meaning, adaptation is connected with extrinsic forces to allow the diversity of form to develop in accordance with the built environment. Peter Pearce, in *Structure in Nature is a Strategy for Design,* exemplifies that snowflakes (fig24) show a great diversity of formal adaptation for its environmental conditions of temperature, humidity, wind velocity and so on.[10] In this sense, adaptation is the process of modification or alteration of a thing so as to suit new conditions.

The next two images show how the form of architecture is adapted by its environmental condition. The initial proposal of Reallon Bridge (fig 25) was not able to be completed due to the steep side of the hill. Instead of the original design, the architect designed a fully fixed support for the lower end, with a rolling support on the hill side. (fig 26) Compared with the original symmetrical form, the resultant form is asymmetric, much like a cantilever. However, the original form seems unstable because the sloping form of the bridge with massive support at both ends makes illusion that the bridge was now falling on one side.

[10] Pearce, Peter. *Structure in nature is a strategy for design.* Cambridge: MIT Press, 1978.

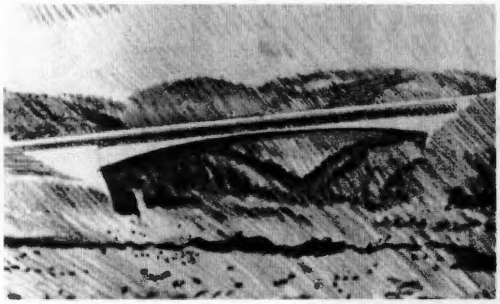

Fig25 Initial Proposal of Reallon Bridge
Source: Zannos

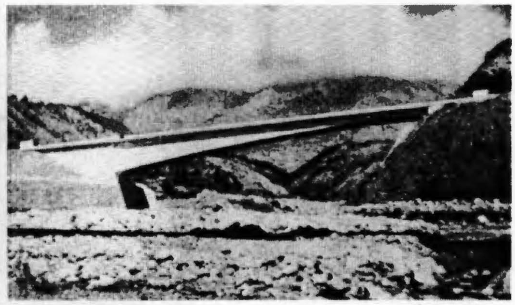

Fig26 Final Proposal of Reallon Bridge
Source: Zannos

The Storefront for Art and Architecture, (fig 27, 28) located on the corner of a block that marks the intersection of three distinct neighborhoods, is the other example of adaptive form in architecture. To overcome the long, narrow space for exhibition, Steven Holl conceived revolving panels which make the interior space of the gallery expand out onto the exterior New York City street. This adaptation is a response to the demand of the modification of building's use over time.

The Corrugated duct house, (fig 29) designed by Neil M.Denari, shows how the corrugated roof form is changed, reacting to the building program and natural environment. As a standardized material, two large, white-painted corrugated steel sheets are mirrored top and bottom to form a roof. The roof is also deformed, through the manipulation of twists and bends, to make the interior space.

The Reichstag, (fig 30) designed by Norman Foster, is another example in terms of standardization and adaptation. In this project, instead of rebuilding the historical dome, designer kept the original form but changed its structure and materials. (fig 31, 32) The intention of the transparent cupola is to reflect the history of the building, its present, and its future. Also, the image of the new dome has two aspects of German unity: the form recalls its roots in the past, but on the other hand, new technology points to its future.

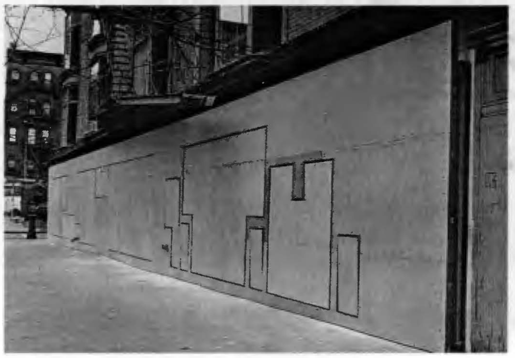

Fig27 Storefront for Art and Architecture Source: Holl

Fig28 Adaptive form of Storefront for Art and Architecture Source: Holl

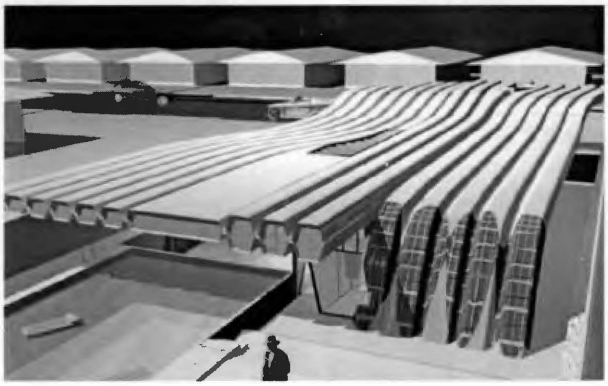

Fig29 Corrugated Duct House Source: Author

Fig30 The Reichstag Source: Foster

Fig31 Original form of the Reichstag
Source: Foster

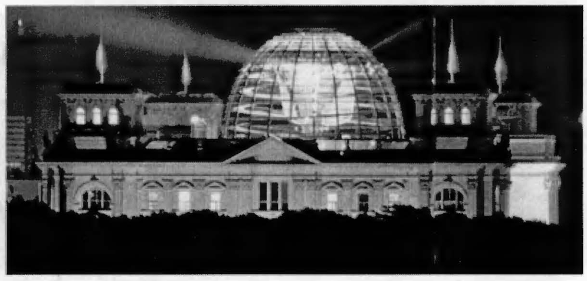

Fig32 New form of the Reichstag
Source: Foster

In conclusion, the architectural form should be reflected in the interaction of intrinsic forces and extrinsic forces. Through the process of standardization and adaptation, which are interrelated to intrinsic forces and extrinsic forces, architectural form should accomplished a state of equilibrium.

3. Site Selection

Columbus is "showcase of modern architecture".

The process of the generation of architectural form necessarily responses to the extrinsic forces and the intrinsic forces which already exist on the site. The goal of the architect should be to reinterpret the forces on the site and to generate a new form according to those forces. The site for this thesis exploration is Columbus, Indiana, as seen in figure 33.

From 1942, a lot of modern buildings have been built by famous architects, such as Eliel Saarinen, I.M. Pei, and Richard Meier. Those buildings communicate with each other and the whole city has grown. Figure 34 shows that the development of historical and contemporary architecture in Columbus.

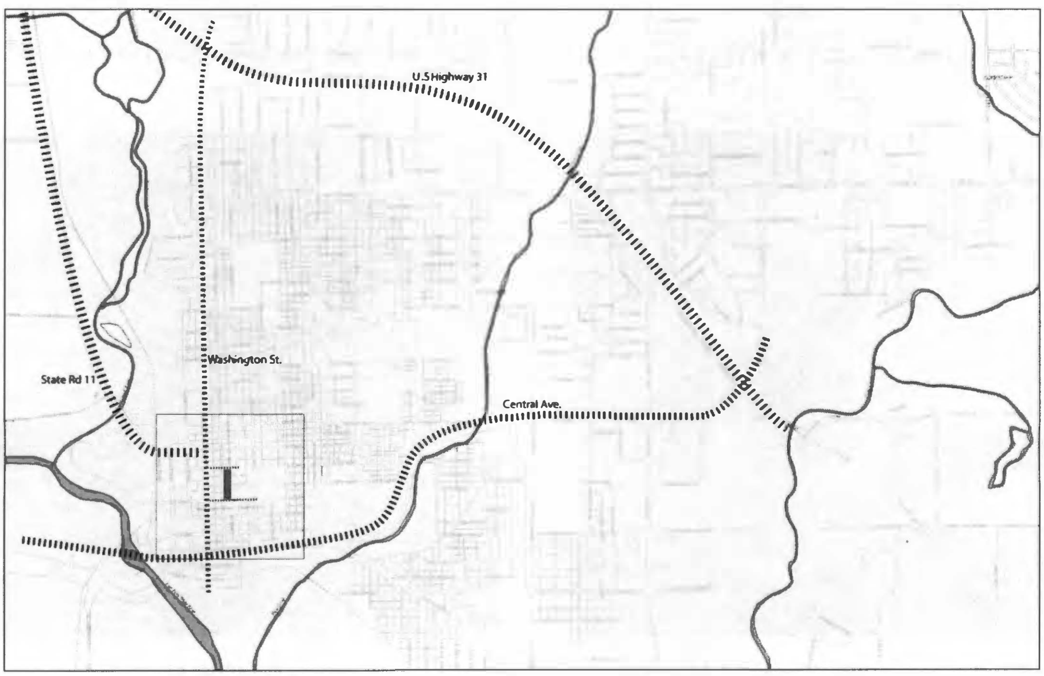

Fig33 Columbus, Indiana Source: Author

Overview

The history of architecture in Columbus began in the 19^{th} century. The desire to make Columbus the best community made people build this famous city.

As the city grew in the last half of the 19th century, many of the city's finest architectures were built at that time, including the Bartholomew County Courthouse (fig 35), completed in 1874. The Courthouse, the old City Hall (fig 36), McKinley School and Garfield School are main examples of the period's architecture.

The first modern architecture in Columbus is the First Christian Church (fig 37) designed by the Finnish architect Eliel Saarinen as a break with traditional Romanesque and gothic structures. Its simplicity and boldness have affected the contemporary church architecture in America. After that, a series of buildings were designed by famous architects. The next notable modern building is Irwin Union Bank, designed by Eero Saarinen in 1954.

Fig35 Bartholomew County Courthouse
Source: Columbus

Fig36 Old City Hall
Source: Columbus

Fig34 Architectural History of Columbus Source:

Fig37 First Christian Church Source: Columbus

In 1957 Cummins Engine Company offered to pay the architect's fee for any new school that was designed by an architect selected from a list supplied by the Foundation. Due to this proposal, a number of school buildings have been designed in Columbus. Later, they expanded the program to include a variety of public buildings. In 1963, the building of the Cleo Rogers Memorial Library (fig 38), designed by I.M. Pei, provided the city with civic space in the best architectural tradition. This building's greatest achievement is the architecture outside of the library – the public space made by the library, the Irwin House, and the First Christian Church. At the request of Pei, Henry Moore's Bronze Arch was added to the center of the space to pull the three buildings together. To this day, the new experiment in architecture is being made in Columbus.

Fig38 Cleo Rogers Memorial Library and Henry Moore's Bronze Arch

Source: Columbus

Location

The thesis site (fig 39) is located to the southwest of the city of Columbus, IN. Primary access is from Franklin Street, which is next to Washington Street, the main street of downtown Columbus. The site is bounded by Franklin St., Lafayette St., 5^{th} St., and 7^{th} Street. To the south it faces to the existing Visitors Center (fig 40), renovated in 1973, and the Cleo Rogers Memorial Library, designed by I.M. Pei. Also, the site is the starting point of the official city tour. To the north it faces to the First Presbyterian Church (fig 41), built between 1872 and 1885. The dramatic tower and spire communicate with the tower of the First Christian Church by Eliel Saarinen. To the west it faces to the Franklin Square (fig 42), renovated in 1970.

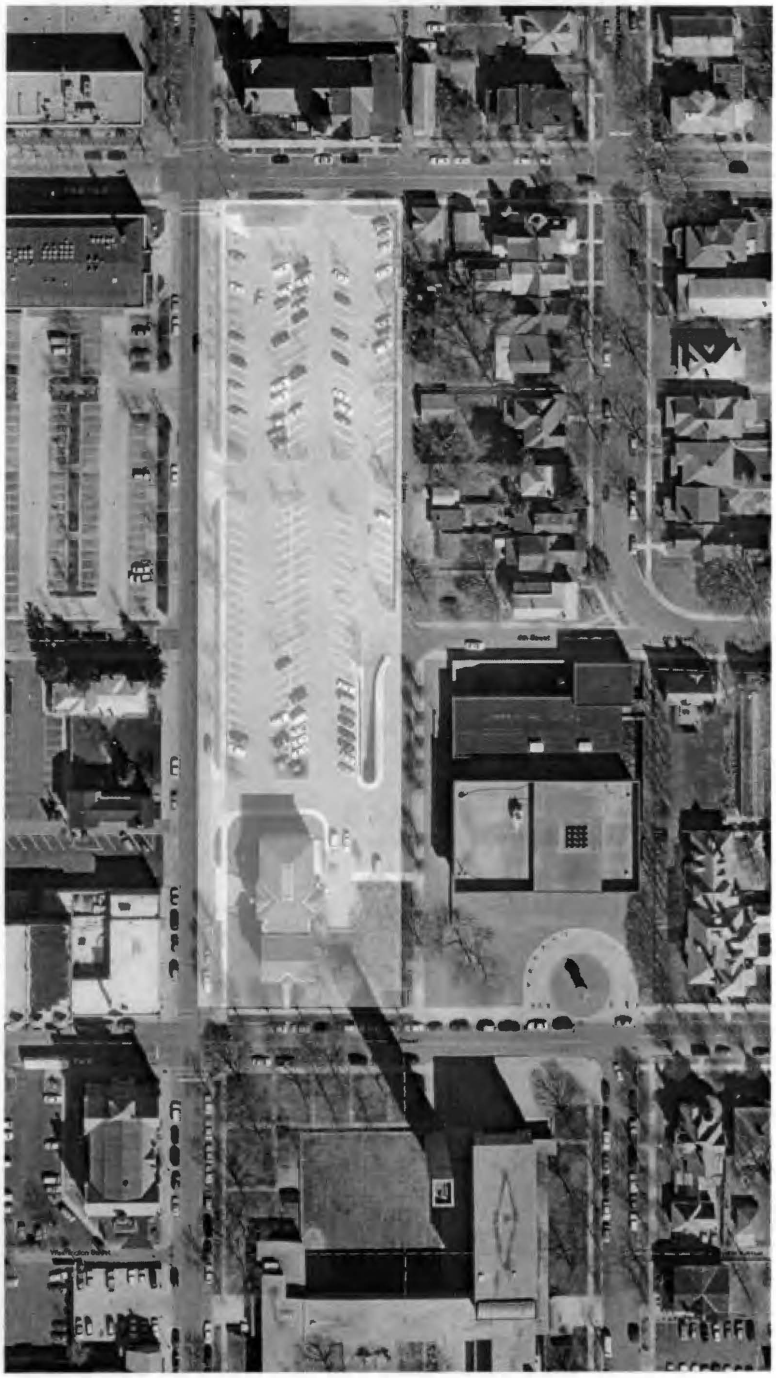

Fig39 Site Arial Photo Source: USGS

Fig40 Existing Visitors Center Source: Columbus

Fig41 First Presbyterian Church Source: Author

Fig42 Franklin Square Source: Author

Site Information and Analysis

The Following (fig 43 – 53) is a diagram of the site information and analysis.

Fig43 Public Outdoor Room Source: Author

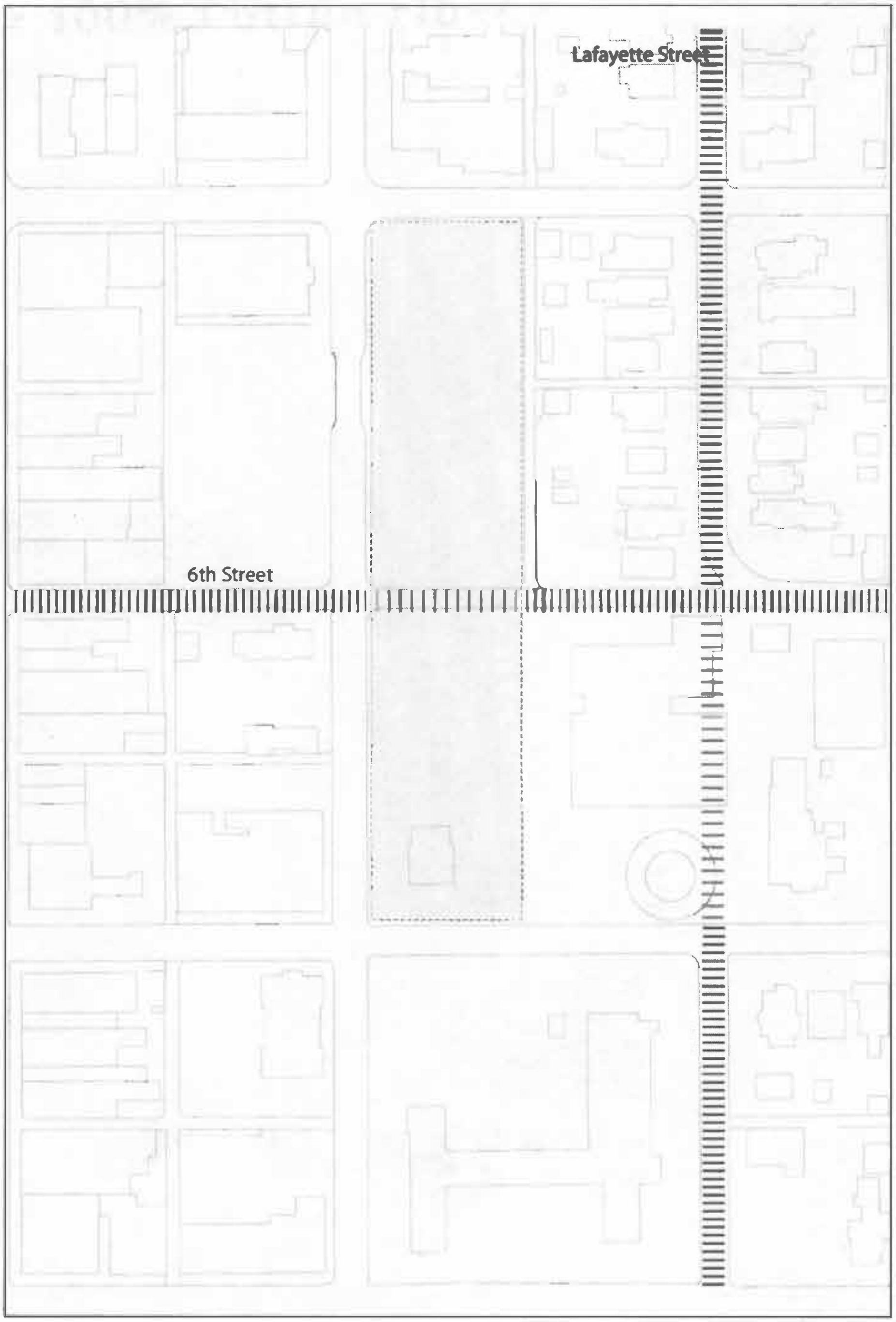

Fig44 Disconnected Street Source: Author

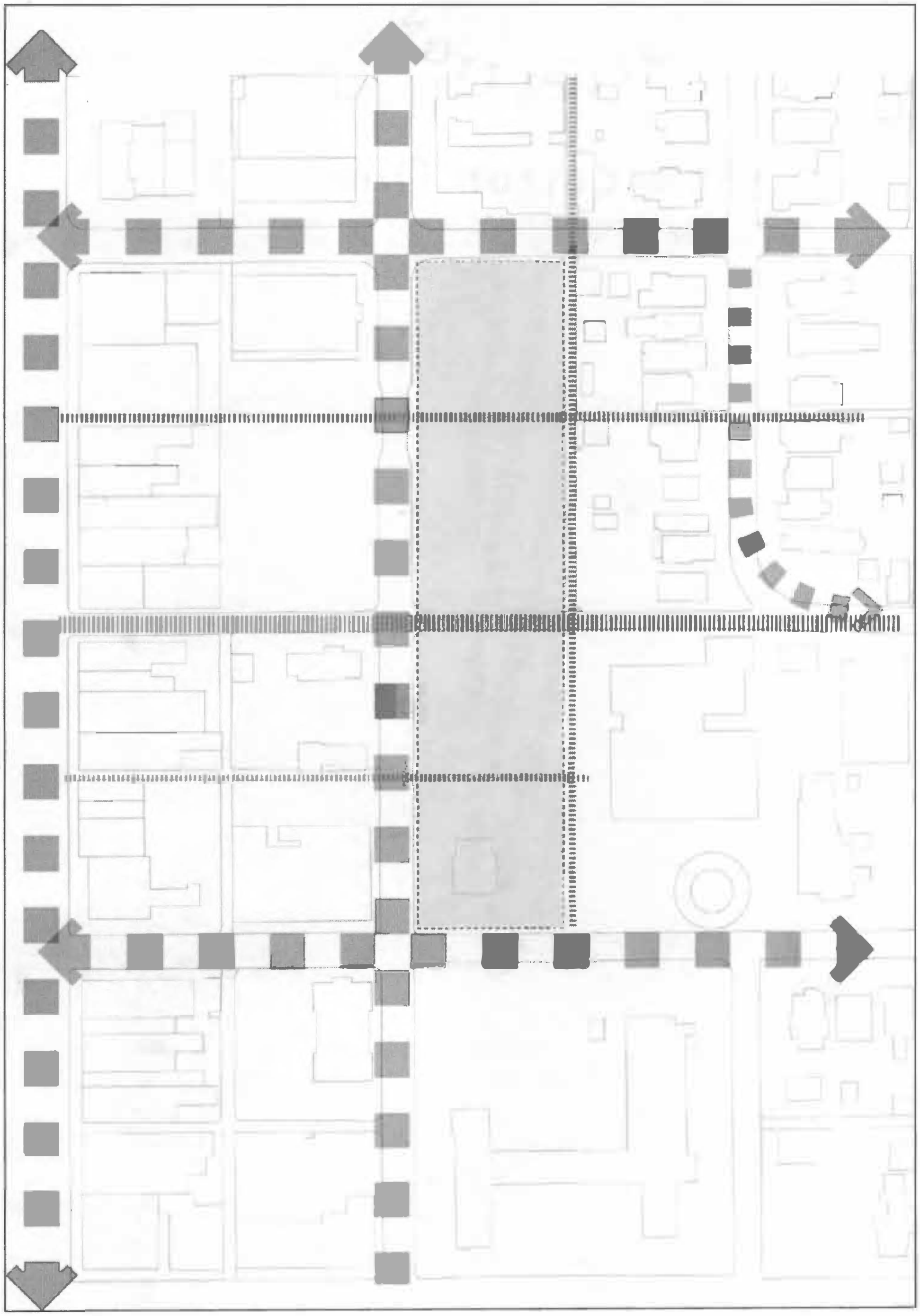

Fig45 Alley   Source: Author

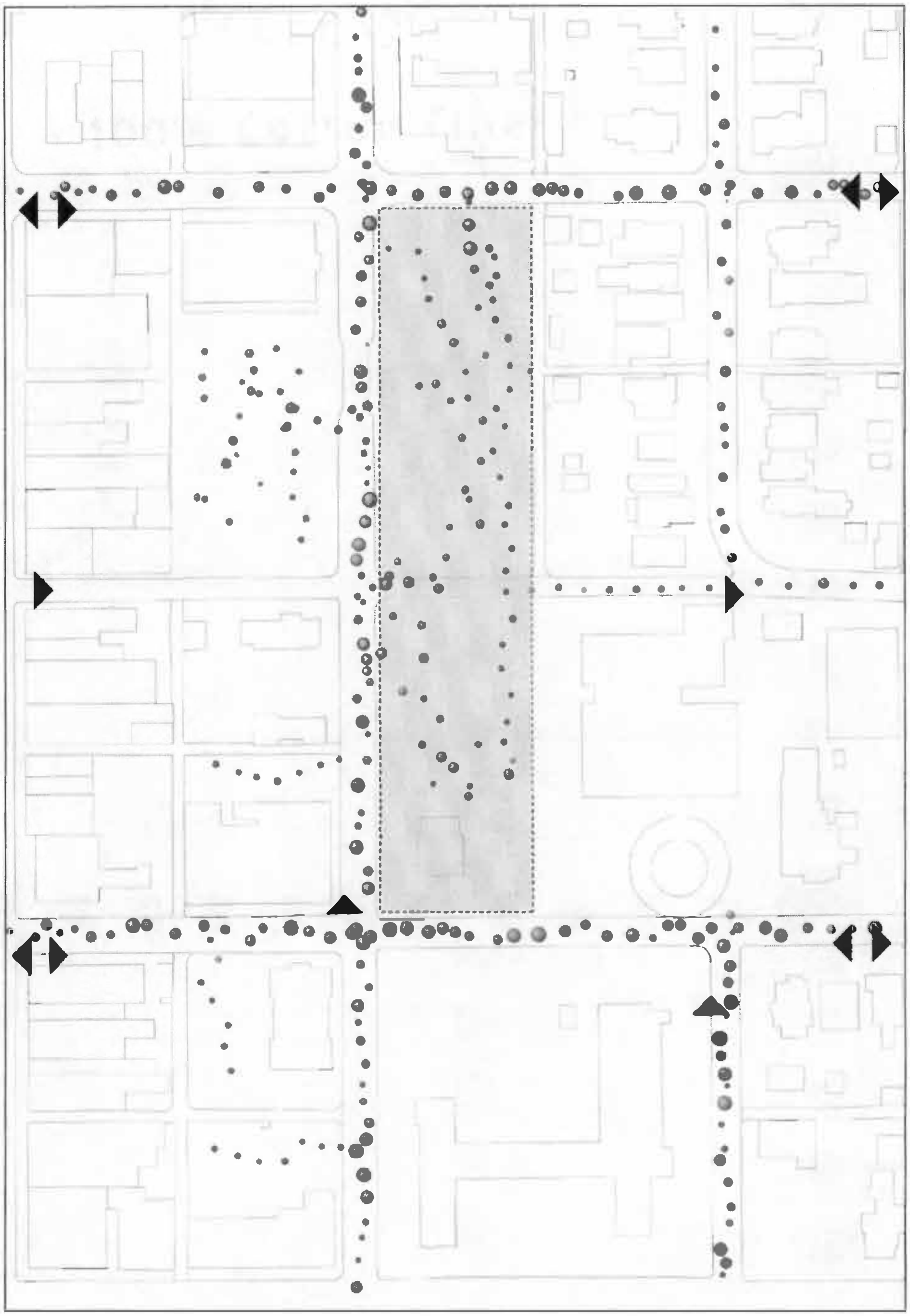

Fig46 Circulation – Car Source: Author

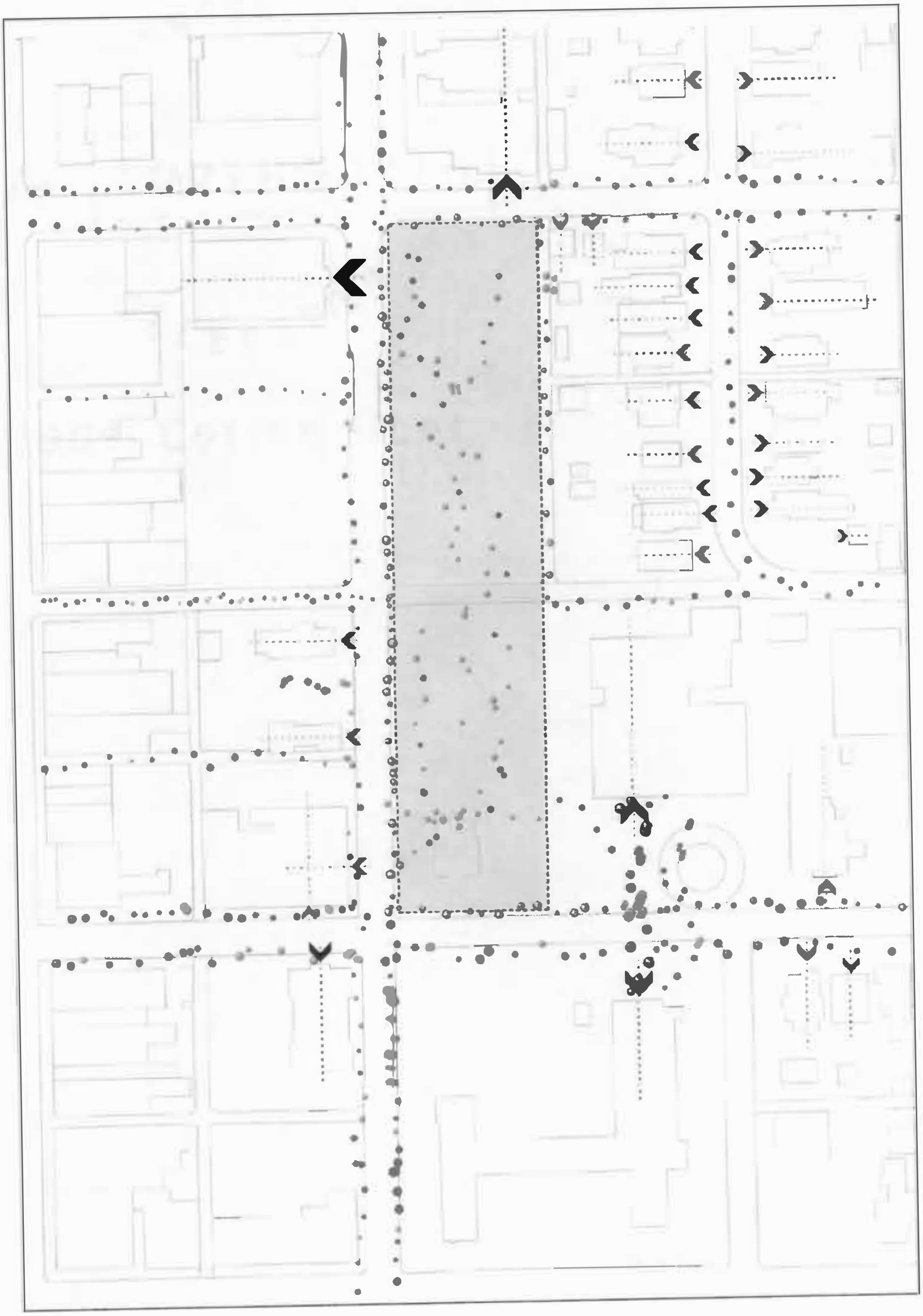

Fig47 Circulation - Pedestrian Source: Author

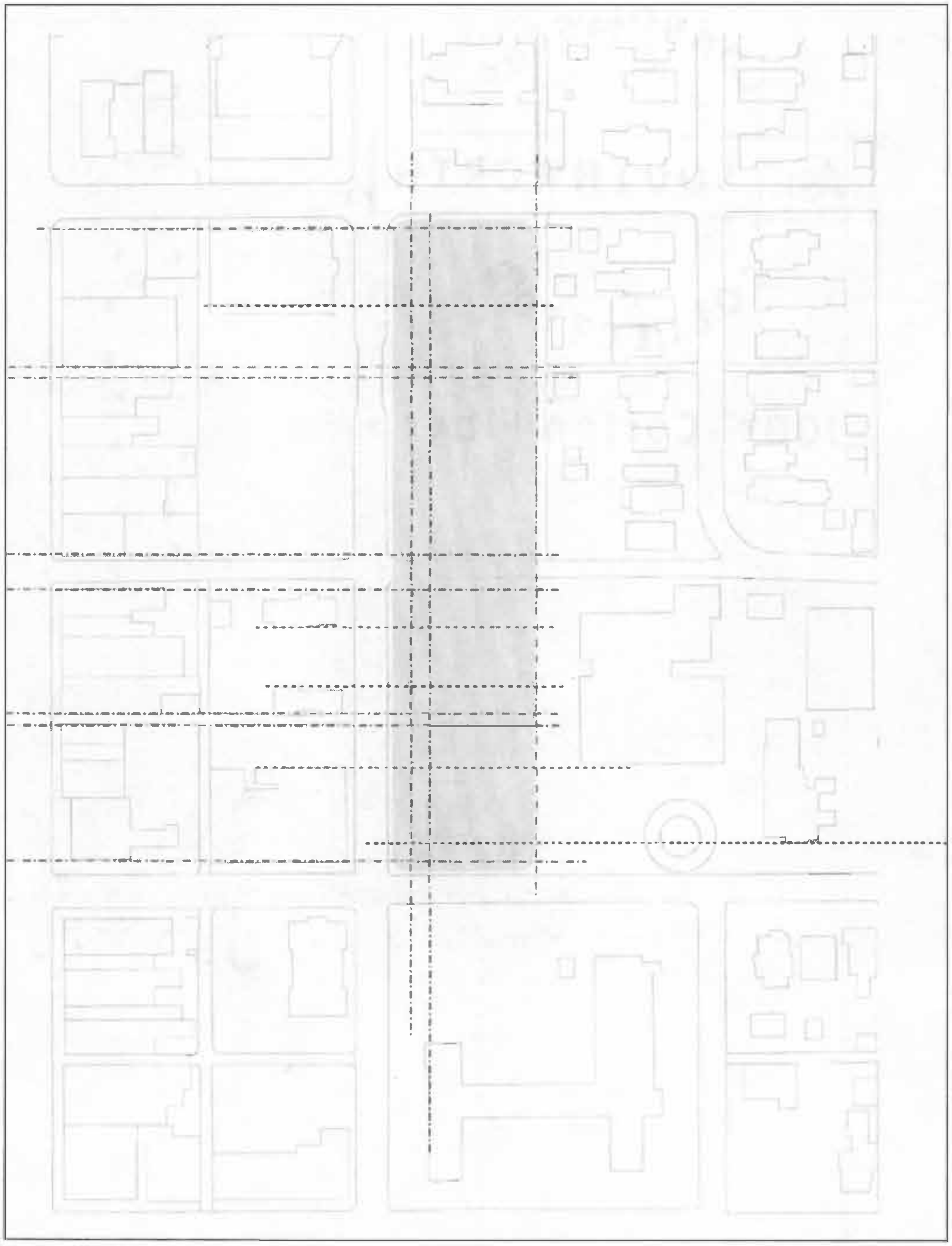

Fig48 Regulation Line Source: Author

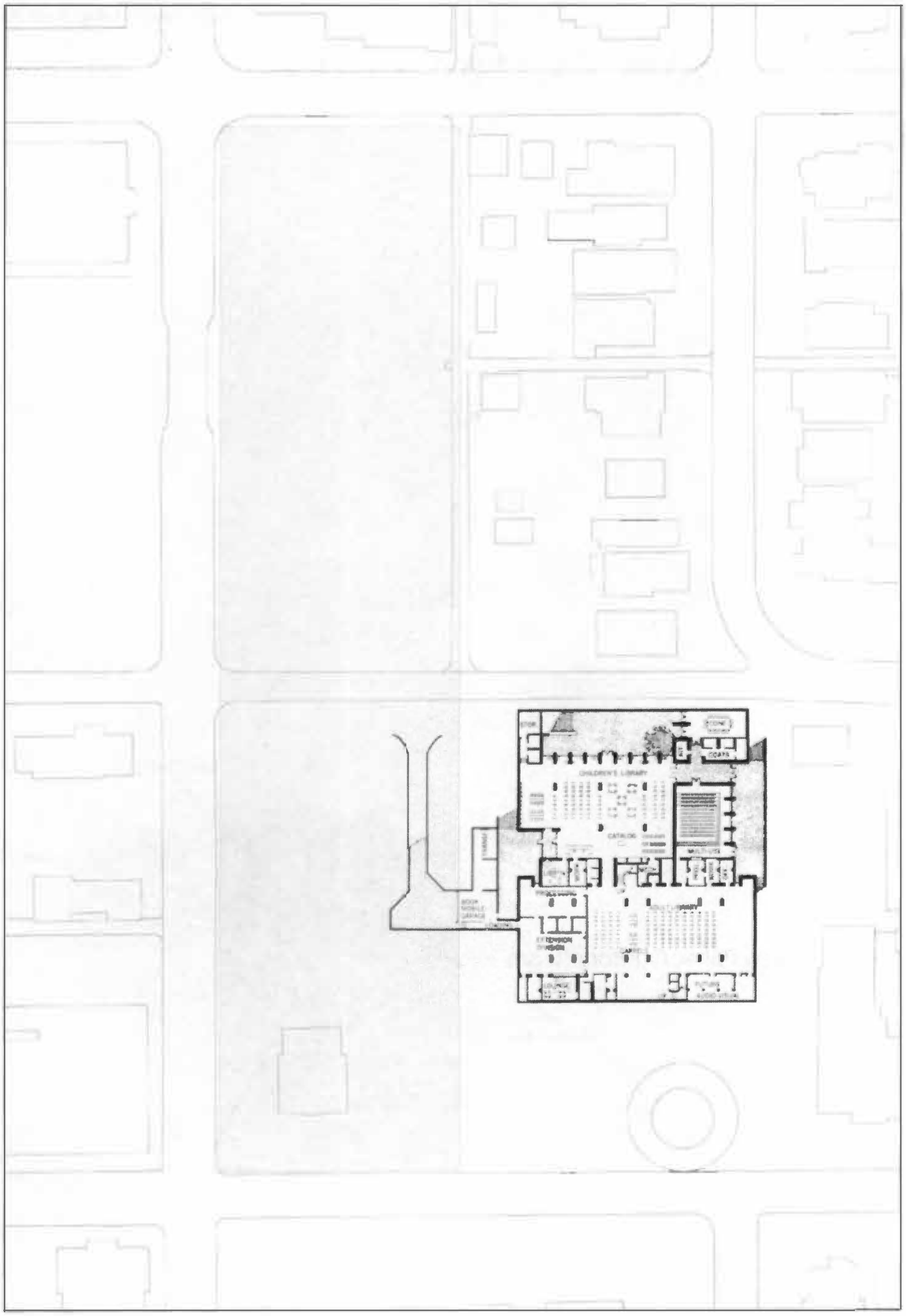

Fig49 Existing Ramp and Share Source: Author

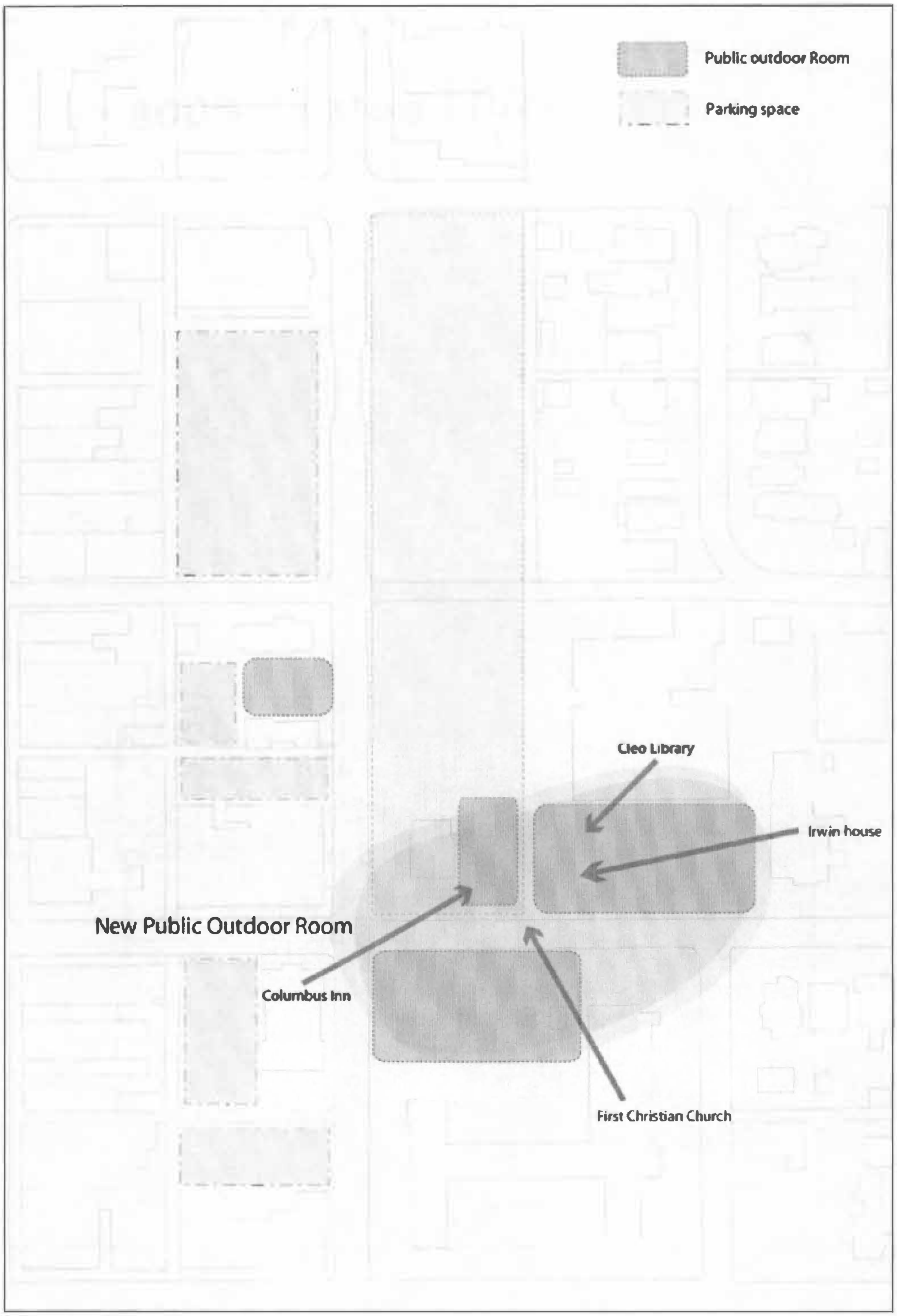

Fig50 New Public Outdoor Room Source: Author

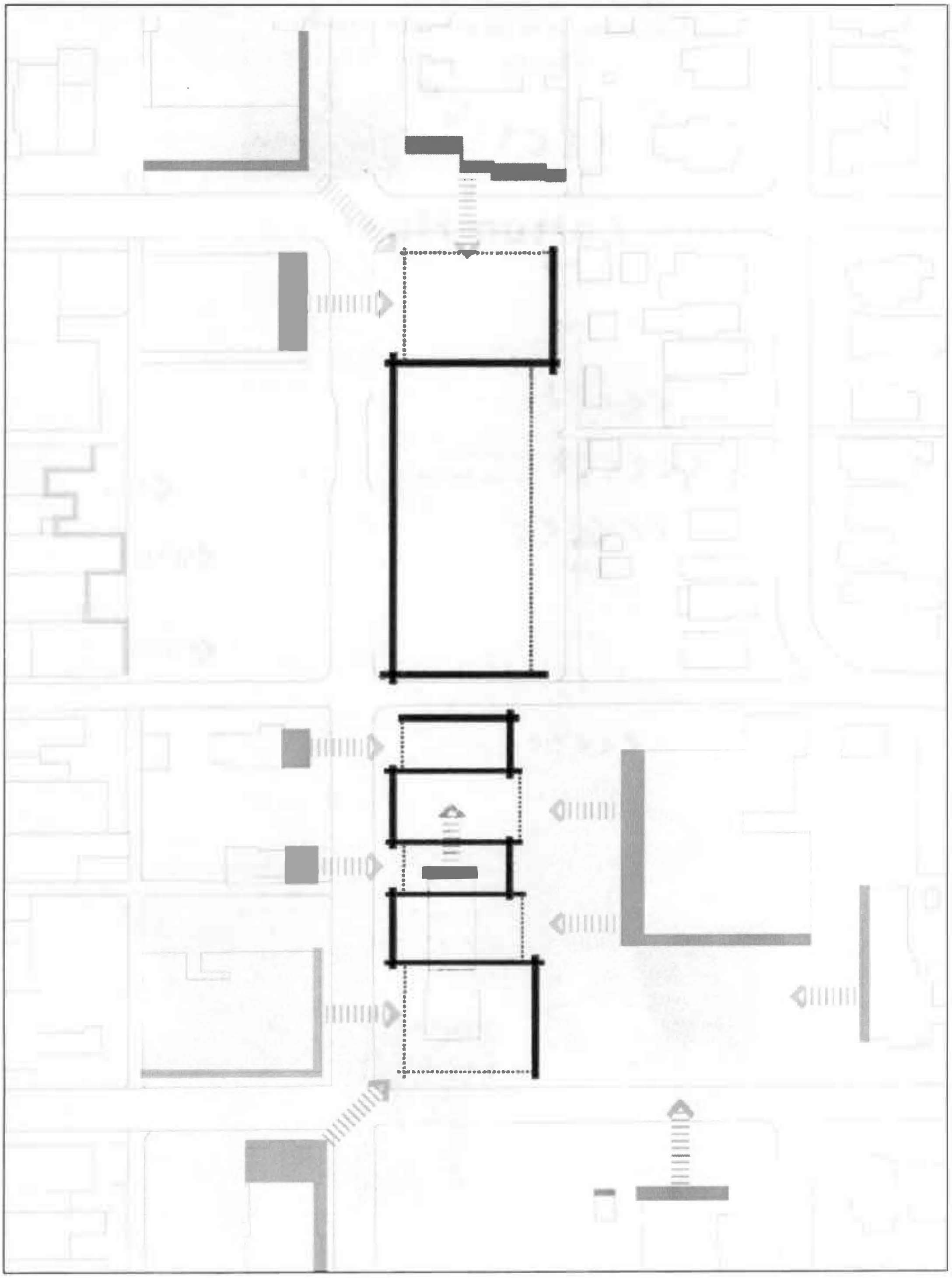

Fig51 Internal Forces to the Site Source: Author

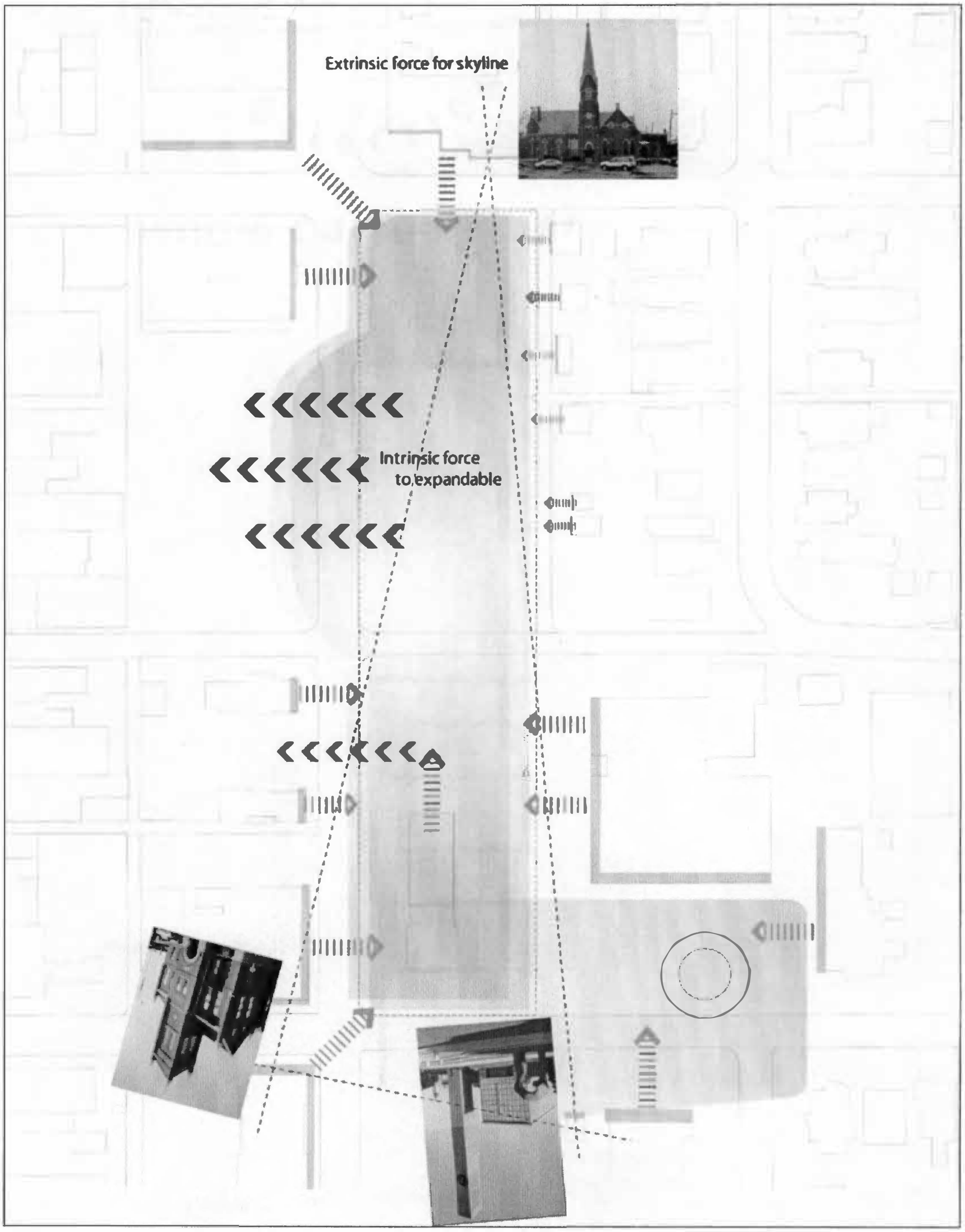

Fig52 External Forces to the Site Source: Author

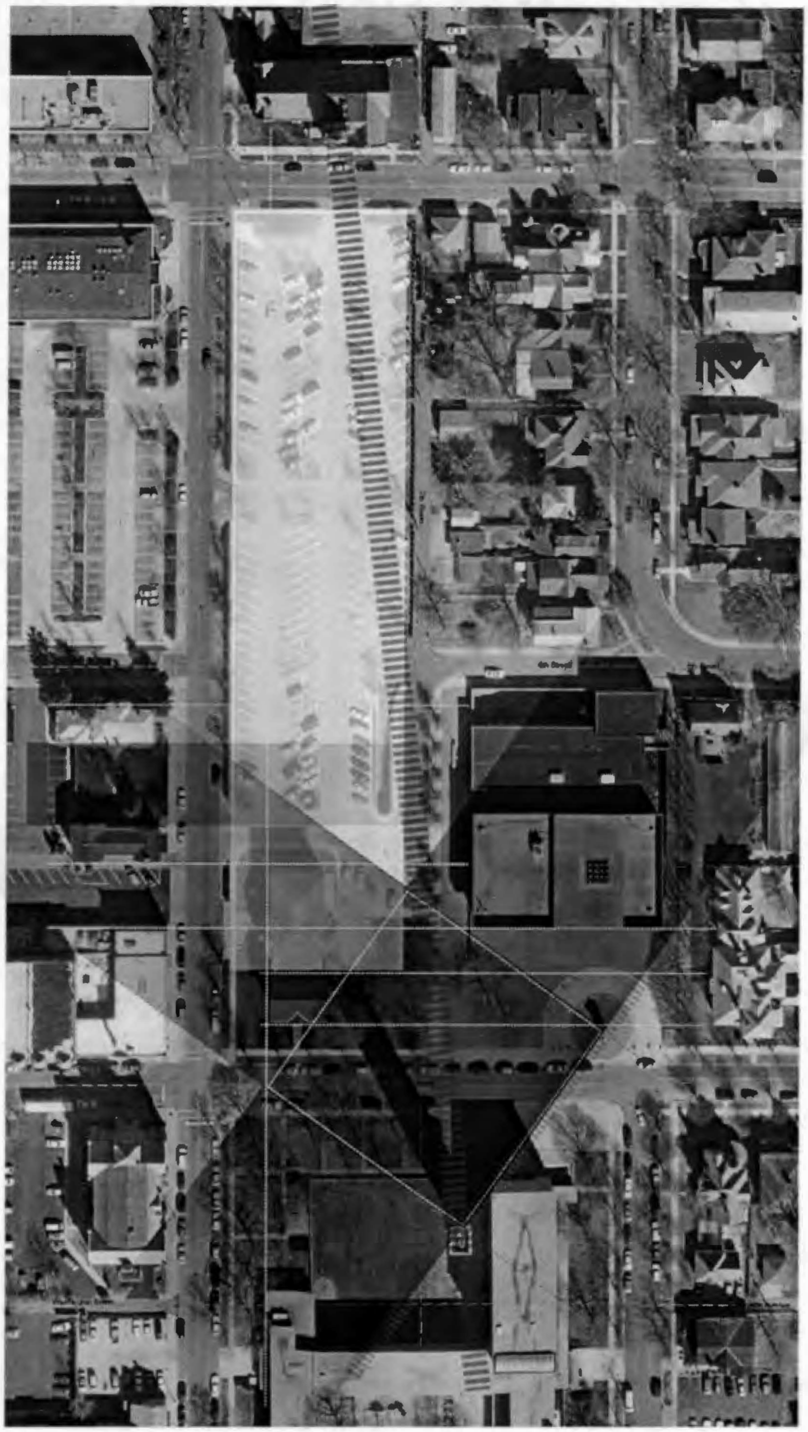

Fig53 External and Internal Forces to the Site Source: Author

4. Program Selection

"In today's city, the museum plays a role analogous to that of the cathedral of yesterday."

- Mario Botta

The program for the thesis project is the Museum of Architecture in Columbus. As Columbus is the "*showcase of modern architecture*", visitors are increasing and a place for city information and history is needed. This architectural Museum will be like the lobby of Columbus and a guide for a historical and contemporary architecture information center. Also, the Museum of Architecture in Columbus will show the development of architecture and the future of architecture in Columbus.

This thesis calls for a challenge and integration of generations of architectural form, which is in response to extrinsic forces and intrinsic forces of the site and the program itself. Also, this architectural form is generated by standardized and adaptive structures or materials which need to interrelated with extrinsic forces and intrinsic forces. Today's museum is no longer just a place for people to gather and appreciate art. In other words, the museum is more than a vehicle for the exhibition, study, and reservation of valuable objects; it represents the highest goals and desires of a society.

The Origin of the Museum

Museums have been among the most architecturally attractive form of buildings of the past few decades. As a building type, the public museum goes back to the late eighteenth century and early nineteenth centuries. Its origins in houses and palaces, where rooms were particularly planned to exhibit works of art, are even earlier. According to Justin Henderson, in his ***Museum architecture,***[11] among the first museums to open to public was the Capitoline Museum (fig 54) in Rome (1734), which was the first public gallery for the display of classical sculpture; the Museo Pio Clementino, a series of galleries added to the Vatican between 1770 and 1786; the Musse du Louvre in Paris (1784 - 1792); and the Dulwich College Picture Gallery in London (1811 – 1814), designed by Sir John Soane. Perhaps the most influential source for museum architecture in the nineteenth century was J.L.Durand's designs for an art museum published in Precis des Leçons d'Architecture (1802 – 1805). Schinkel's Altes Museum (fig 55) represents another significant change: it was conceived as more than a place in which exhibits could be housed and the public could be educated. It was part of a greater scheme of civic improvement and thus further expanded the role of the museum structure in society.

Fig54 Capitoline Museum Source: Jürgen

[11] Henderson, Justin. ***Museum Architecure.*** Gloucester, Rockport Publishers, Inc. 2001 P.7

Fig55 Altes Museum Source: Jürgen

This monumental two-story building with an imposing flight of steps served in turn as the inspiration for such masterpieces as the 1893 design by McKim, Mead & White for The Brooklyn Museum and, even as late as 1941, the National Gallery of Art in Washington, D.C.

The form of the Museum

The objects on display in the museums have an influence on the form of museum. According to Justin Henderson, in his *Museum architecture*,[12] the approach to generating the form of museums has three categories:

- *Form follows not function but content*
- *Form itself is content*

[12] Henderson, Justin. *Museum Architecure.* Gloucester, Rockport Publishers, Inc. 2001 P.11-13

- *Form reflects its context as well as its content*

He illustrates that a historical museum of Chikatsu-Asuka, (fig 56) designed by Tadao Ando is in the first category. Reflecting the contents, Ando designed the museum like a tomb, with much of its interior buried underground.

At Bilbao, Spain, the Guggenheim Museum (fig 57) designed by Frank Gehry is in the second category. The form of Museum itself is content.

Another, Mario Botta's San Francisco Museum of Modern Art (fig 58) is the example of the third category. Mario Botta has created memorable art museums whose distinctly different yet equally monumental styles reflect its context – a busy urban neighborhood.

Fig56 Historical museum of Chikatsu-Asuka
Source: Henderson

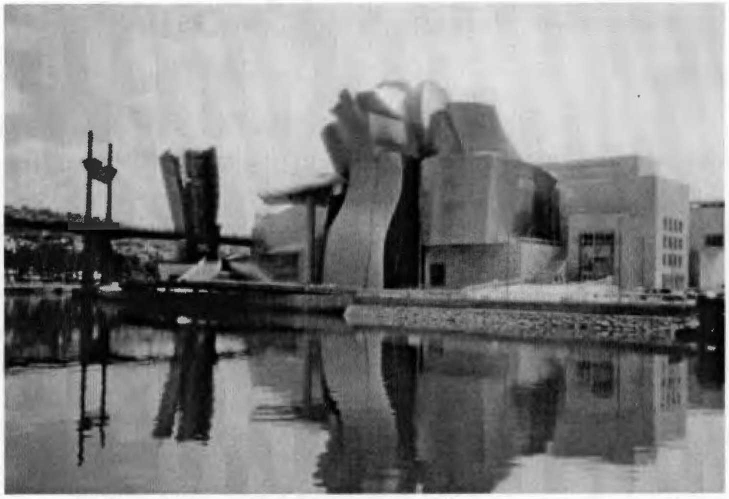

Fig57 Guggenheim Museum Source: Henderson

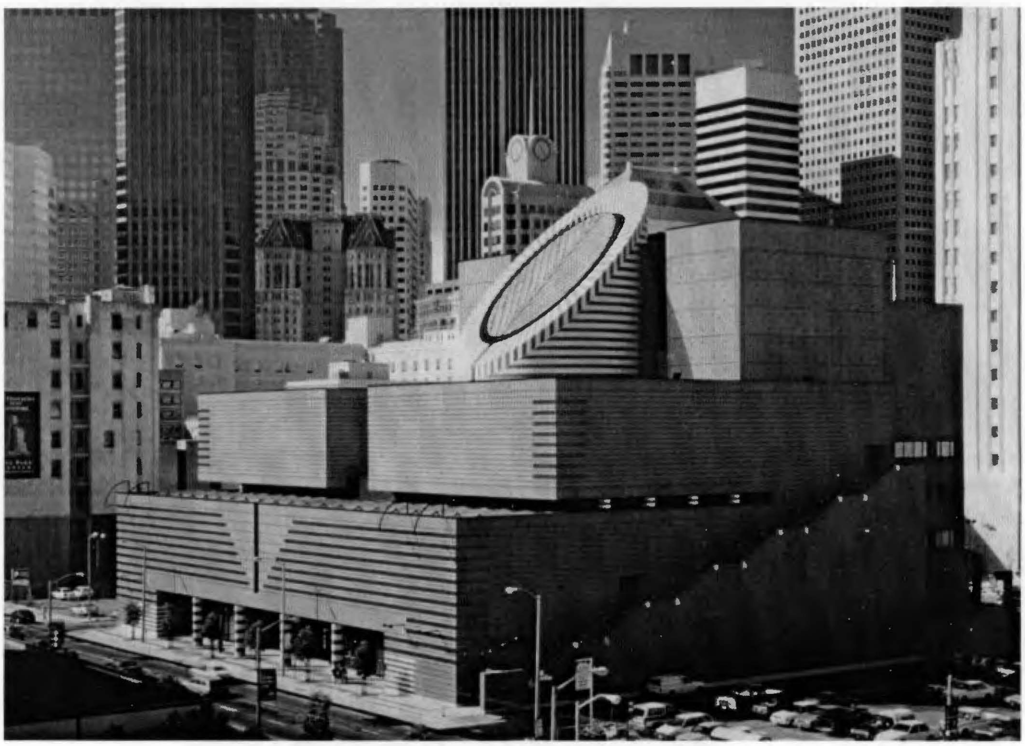

Fig58 San Francisco Museum of Modern Art Source: Henderson

Program Analysis

- Public Areas

    No Collection

    Entrance Hall
    Checkroom
    Admissions
    Information Areas
    A book/gift shop
    Cafeteria
    Auditorium

    Collection

    Exhibition space
    Collection space

- Non-public Area

    No Collection

    Staff space
    Offices
    Meeting room
    Lunch room
    Lounges
    Lockers
    Conference room
    General Storage
    Collection management

Catering Kitchen

Food service/Kitchen

Mechanical equipment

Collection

Collection Loading dock (include shipping and receiving)

Service

Workshops (wood, metal)

Computer room

Security Equipment

Collection Storage

Freight Elevator

5. Project

The first question of this project is how the form expresses the interrelationship of the extrinsic forces and the intrinsic forces of the site. After critical consideration of the site analysis and program analysis an effort is made to apply an informed idea to the project. D'Arcy Wentworth Thompson's quote, "*The form of an object is a diagram of forces*" is the driving force behind all decisions made, both physically and conceptually. However, the project should not be a simple reaction of extrinsic forces or intrinsic forces of the site.

There are two main architectural decisions made at the beginning of the design project. The first step is the defining of the parti by intrinsic forces; standardized patterns of the city and site condition such as regulation line and setback. The second substantial architectural response is that the architectural form of this project is expressed by extrinsic force of the visual connection of the First Presbyterian Church spire (fig 41) and the tower of the First Christian Church (fig 37) by Eliel Saarinen, which means the connection of old and new architecture in the city. Figure 59, 60 shows the preliminary parti diagram of the project.

The exploration of parti studies was made through sketch models and rough sketch drawings to investigate the relationship and ideas of the patterns of the site. (fig 61-63) The preliminary parti of the project shows two different grids; standardized and adapted city axis. It acts to redesign the existing public space made by the Cleo Rogers Memorial Library, the Irwin House, the First Christian Church, and Henry Moore's Bronze Arch.(fig 64) The new development of the site will allow for the creation of new lobby space for the citizen and visitors.

Therefore, the buildings in this city grow and learn from themselves and show an understanding of the future way of the city.

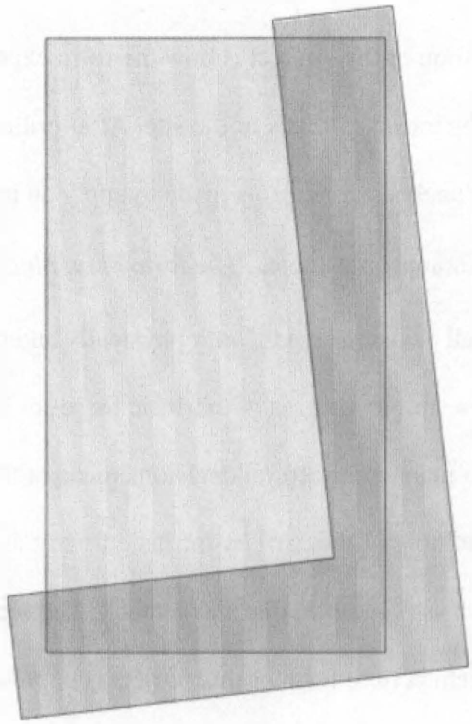

Fig59 Parti Diagram (plan)
Source: Author

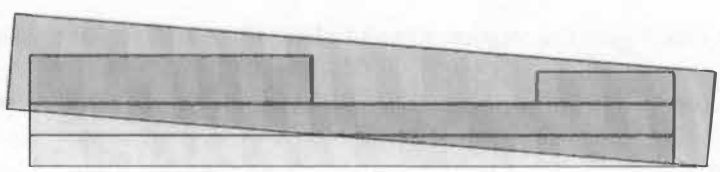

Fig60 Parti Diagram (Section)
Source: Author

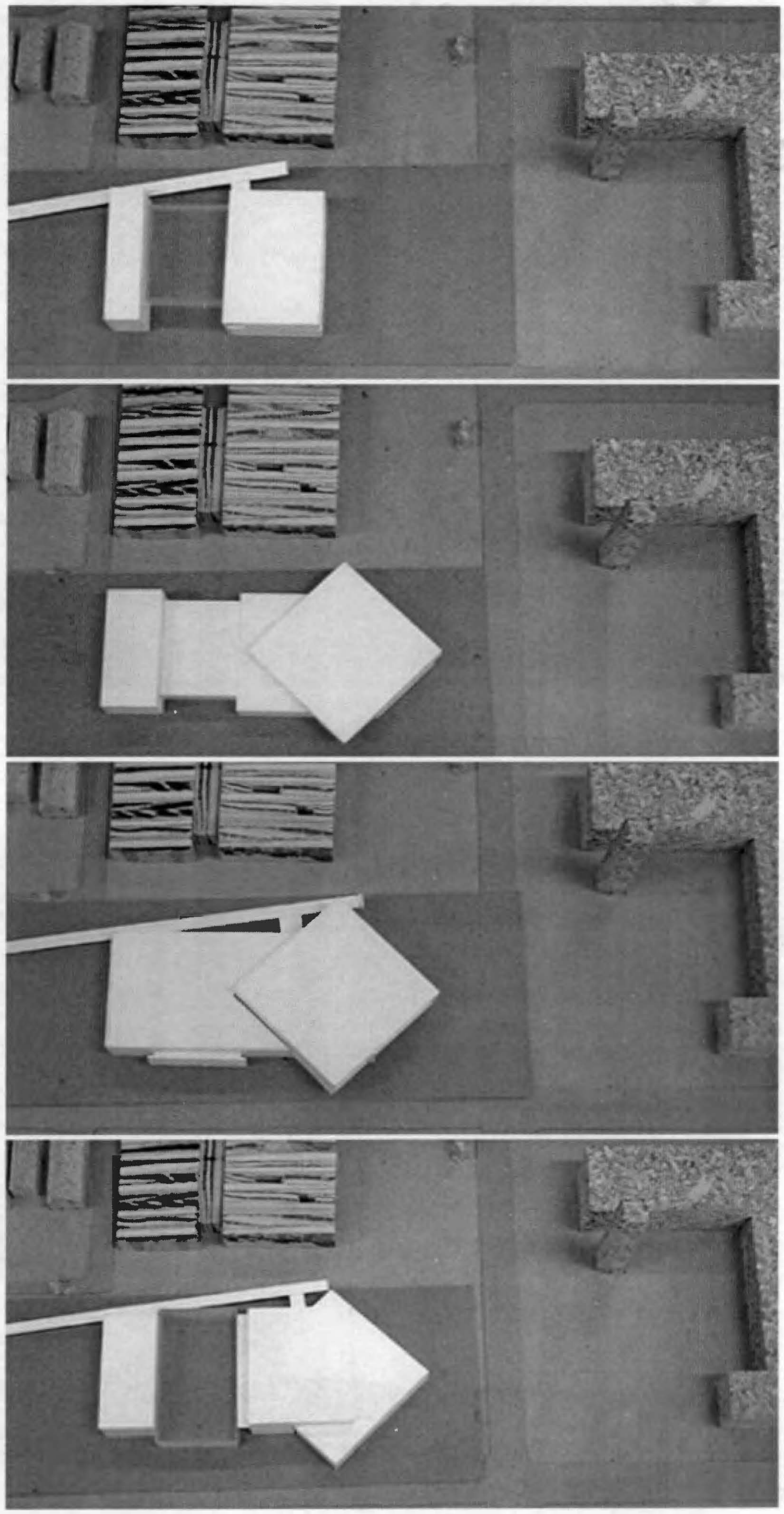

Fig61 Sketch Parti Model Source: Author

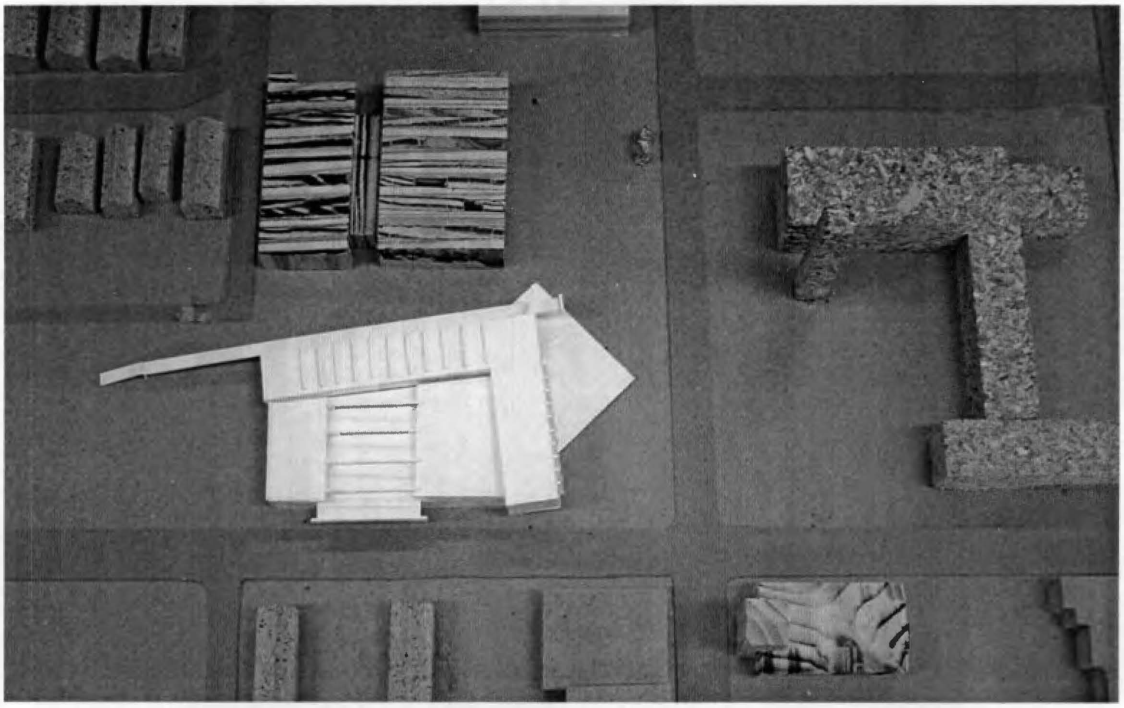

Fig62 Preliminary Parti Model (exterior) Source: Author

Fig63 Preliminary Parti Model (interior) Source: Author

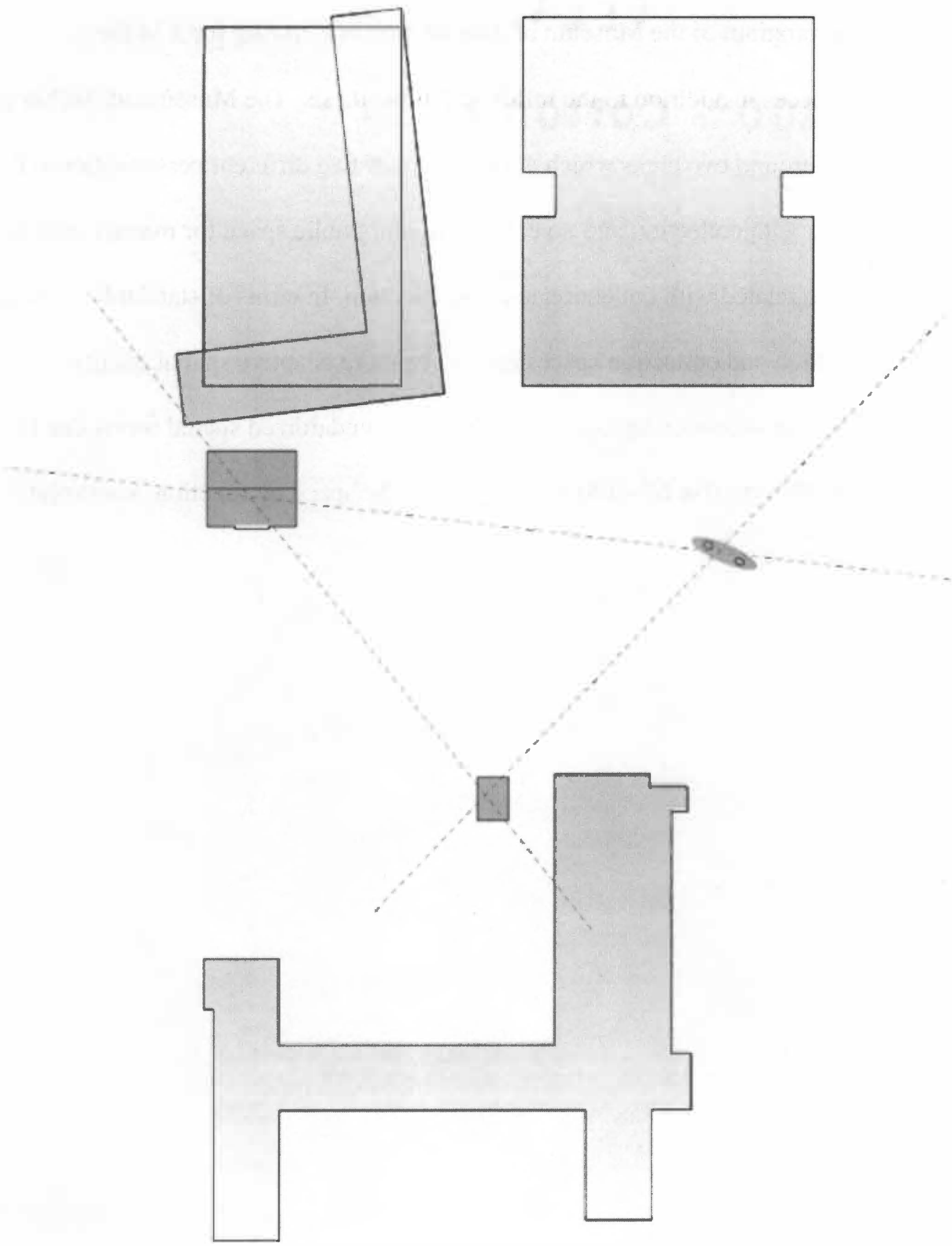

Fig64 New Public Space Source: Author

Also, the program of the Museum of Architecture is a driving force in the development of spaces in addition to the influence of this thesis. The Museum of Architecture program revolves around two areas which are inclusive of two different personalities of the space: public areas with collection and no collection; non-public space for management and administration also related with collection and no collection. In terms of standardization and adaptation, exhibition and collection spaces need to be more adaptive spatial quality; management and administration spaces should be more standardized spatial forms due to efficiency. The Following (fig 65 – 68) is a diagram of the space by function, void/solid, circulation, and service.

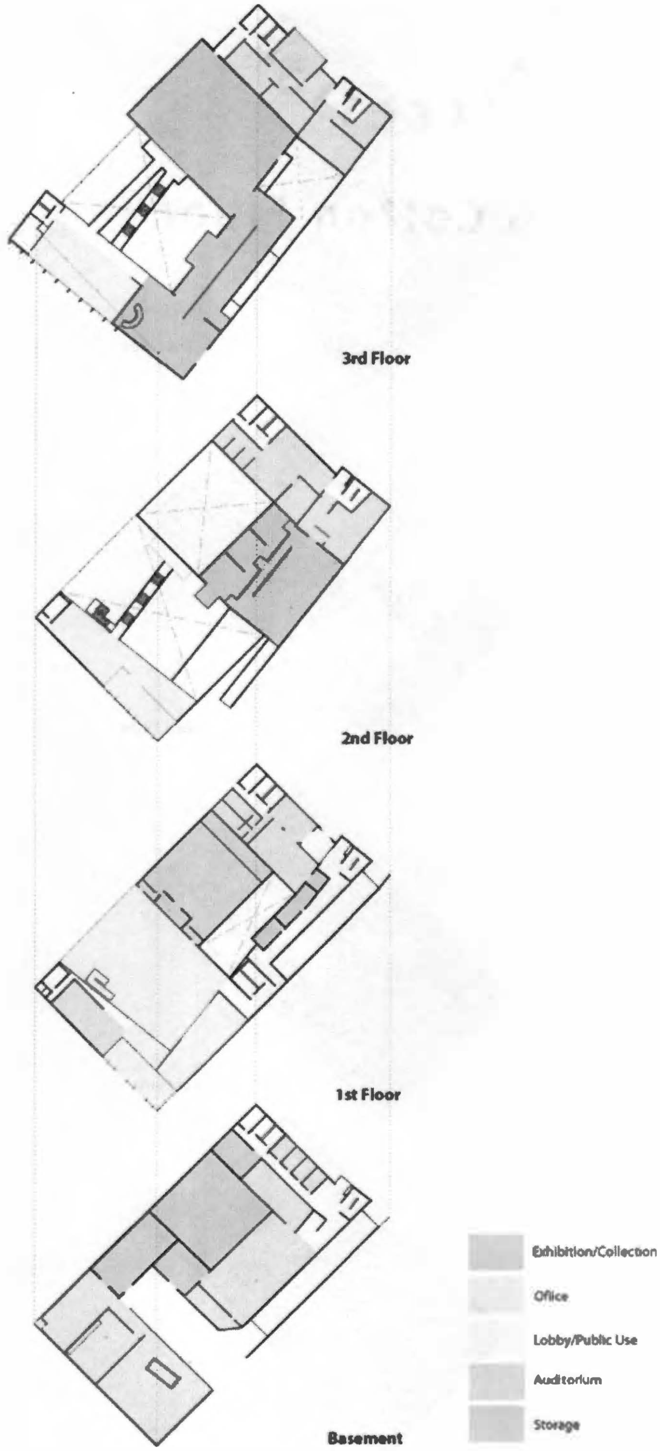

Fig65 Function Source: Author

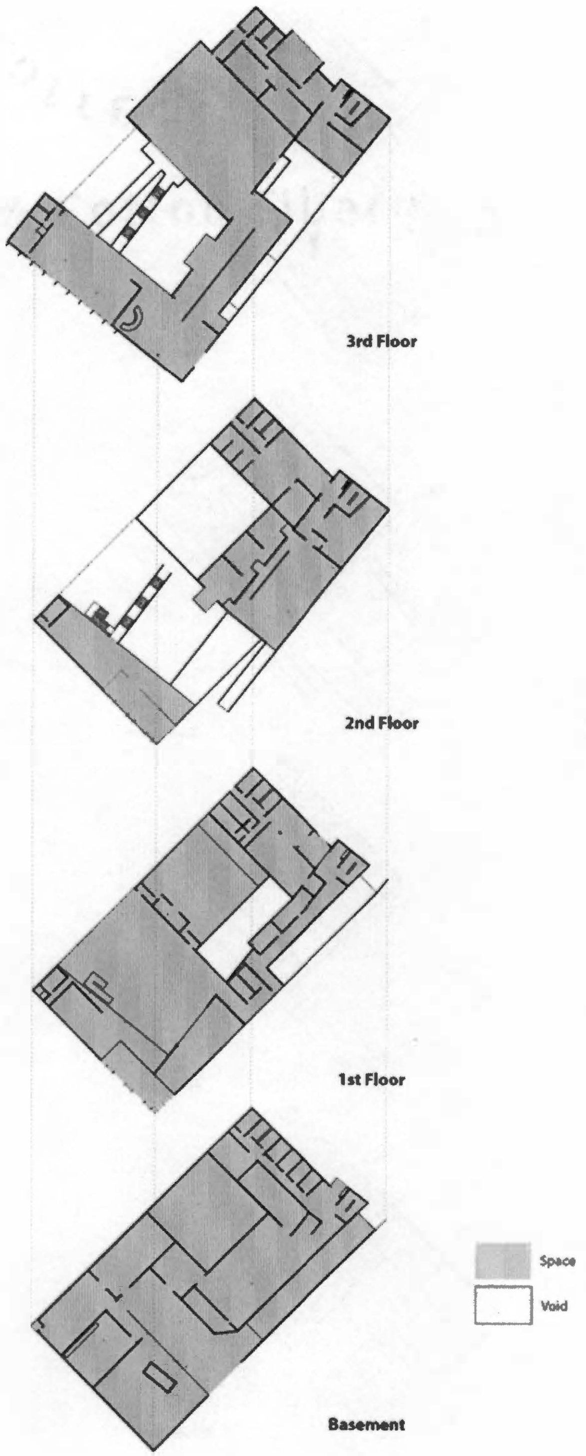

Fig66 Solid/Void Source: Author

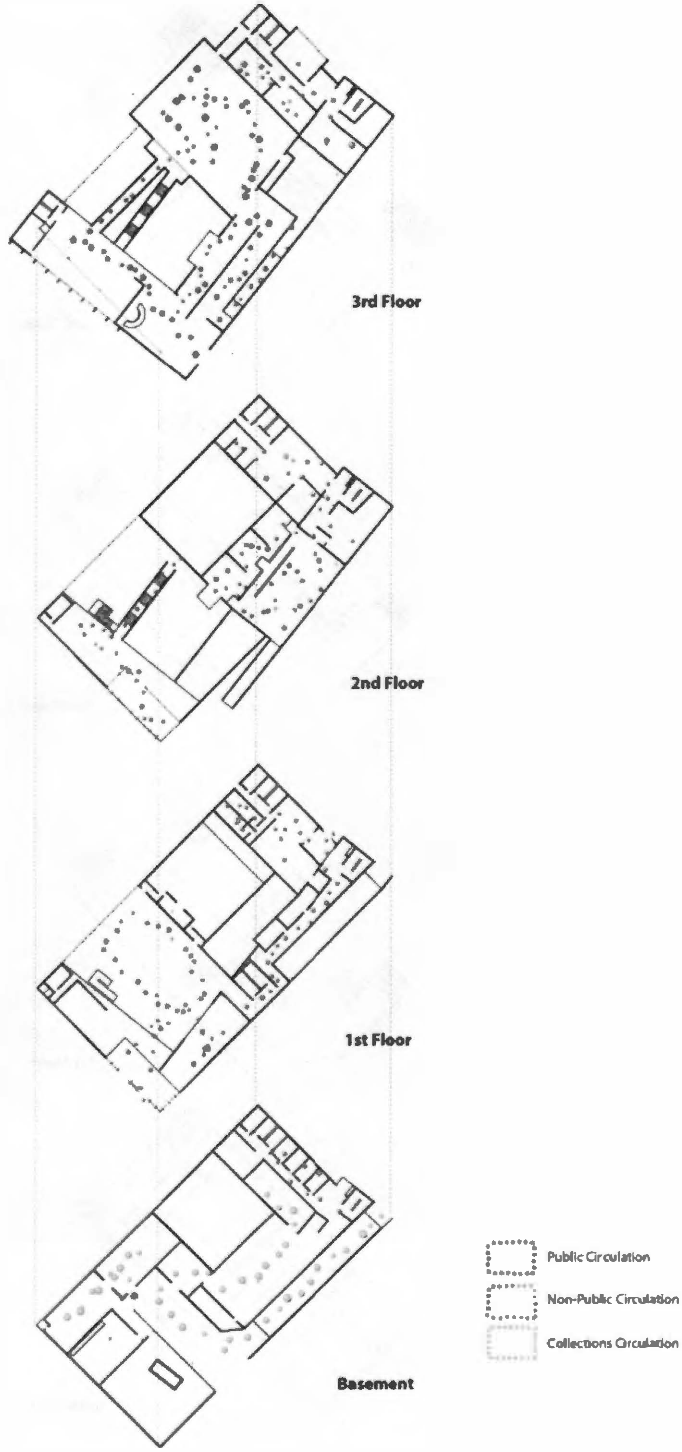

Fig67 Circulation Source: Author

Fig68 Service Source: Author

6. Conclusion

This Museum of Architecture in Columbus is designed using a number of different influences such as extrinsic forces and intrinsic forces with the process of standardization and adaptation. The primary influence is the quote of D'Arcy Wentworth Thompson, "*The form of an object is a diagram of forces*" and the attempt to express the interrelationship of the two forces. During that process, there were a lot of studies and attempts to make the architectural form as a diagram of forces. The second big influence on this project was the research into site analysis and site simulation with models of what the author has found critical during his learning. Approaches, outdoor spaces, places for community to gather, circulation for exhibition and management, views, and spatial quality are all part of the personal biases put into the project. Finally, the program selection itself is highly influential in the generation of space and how material and structural elements fit together.

This project acts as a focal point of the city and landmark to represent the modern architecture in Columbus. An architectural form generated by neighbors and existing public spaces allows the immediate area to come alive. The Museum of Architecture in Columbus serves as lobby as it provides a logical base from which citizens and visitors can orient themselves and from which they can discover what the area has to offer.

7. Project Presentation

The following (fig 69 – fig 82) is a presentation of the drawings of the project.

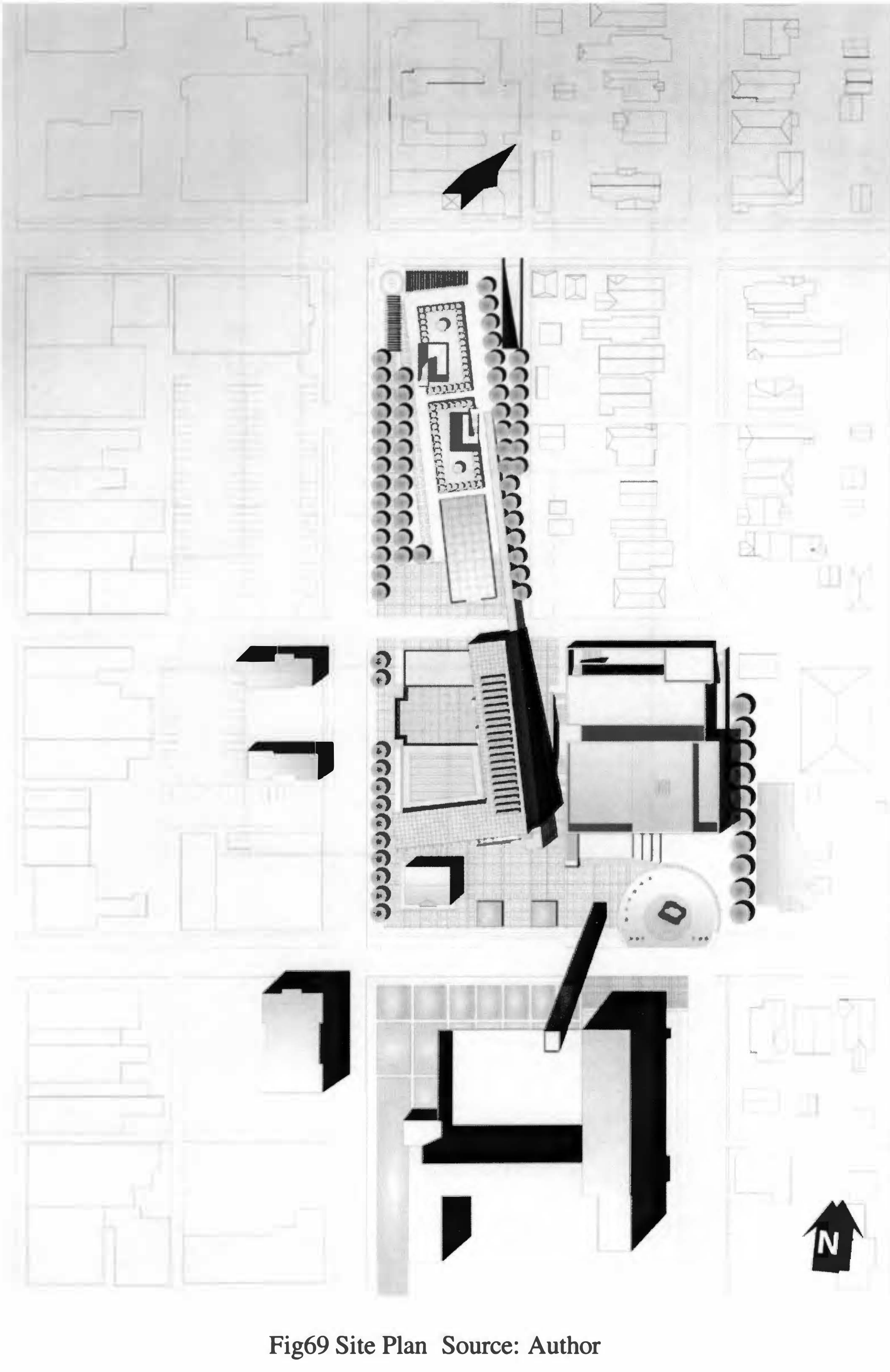

Fig69 Site Plan Source: Author

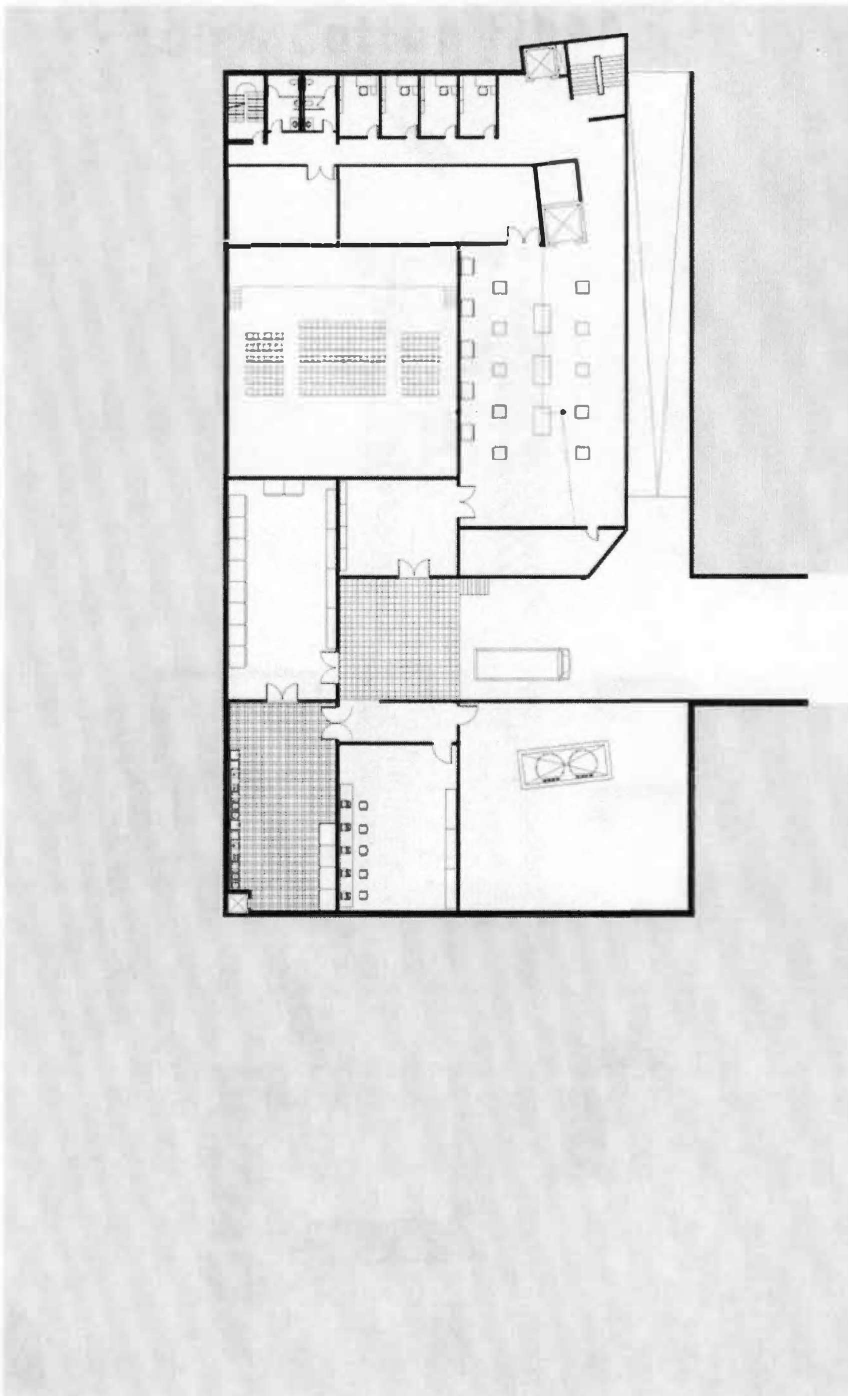

Fig70 Basement Floor Plan Source: Author

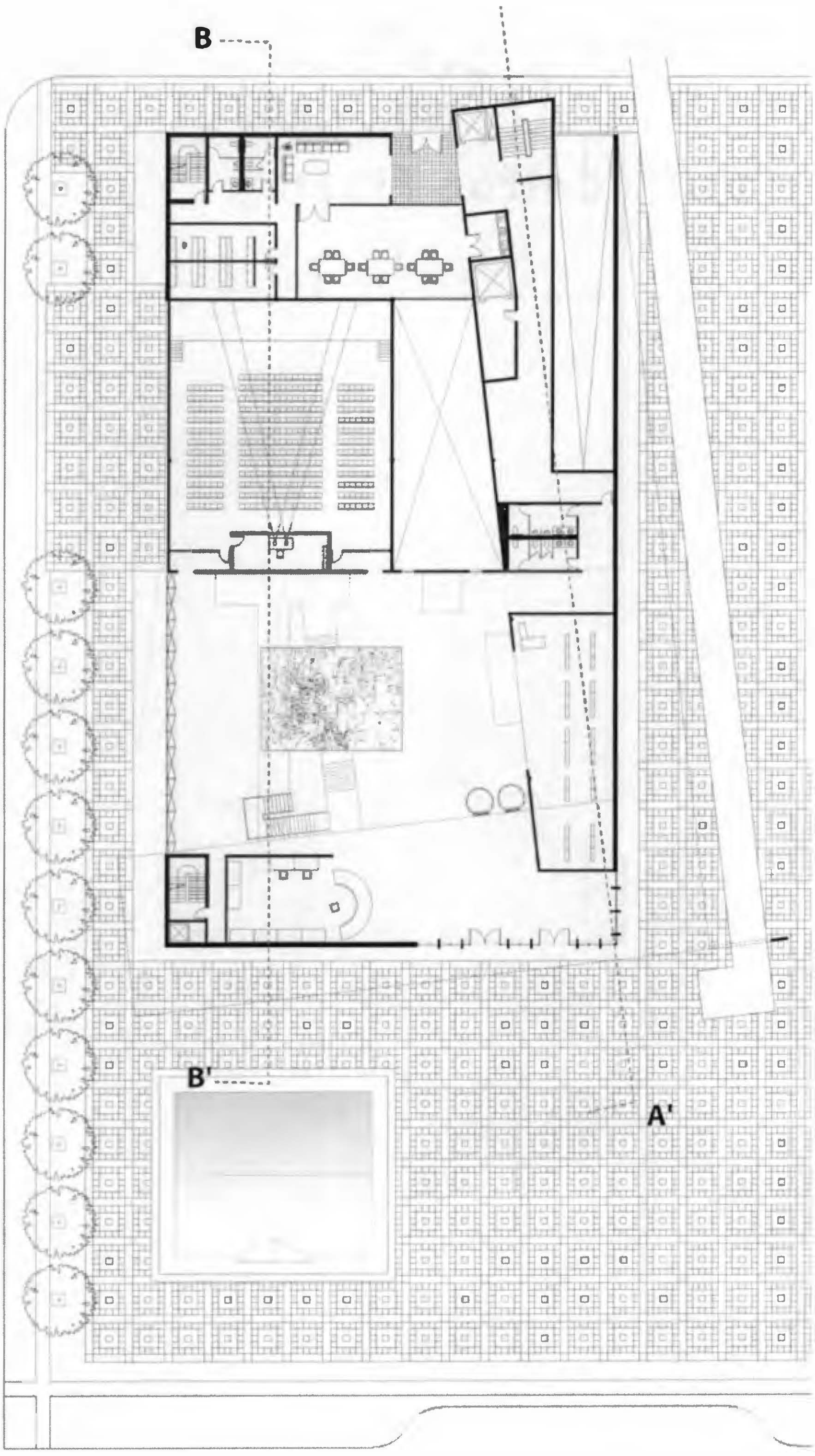

Fig71 1st Floor Plan Source: Author

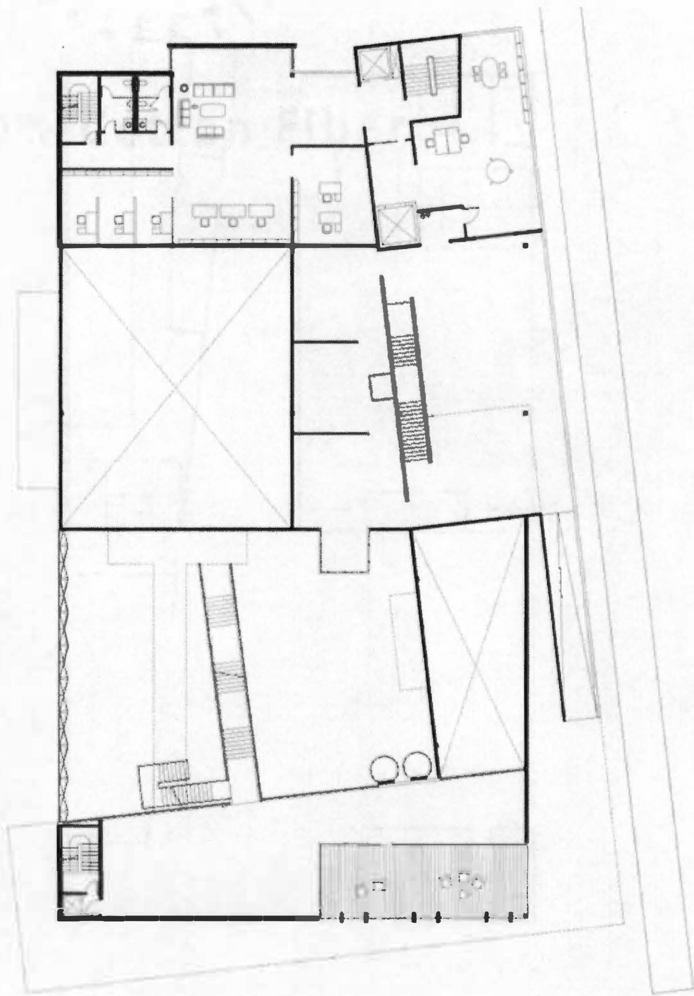

Fig72 2nd Floor Plan Source: Author

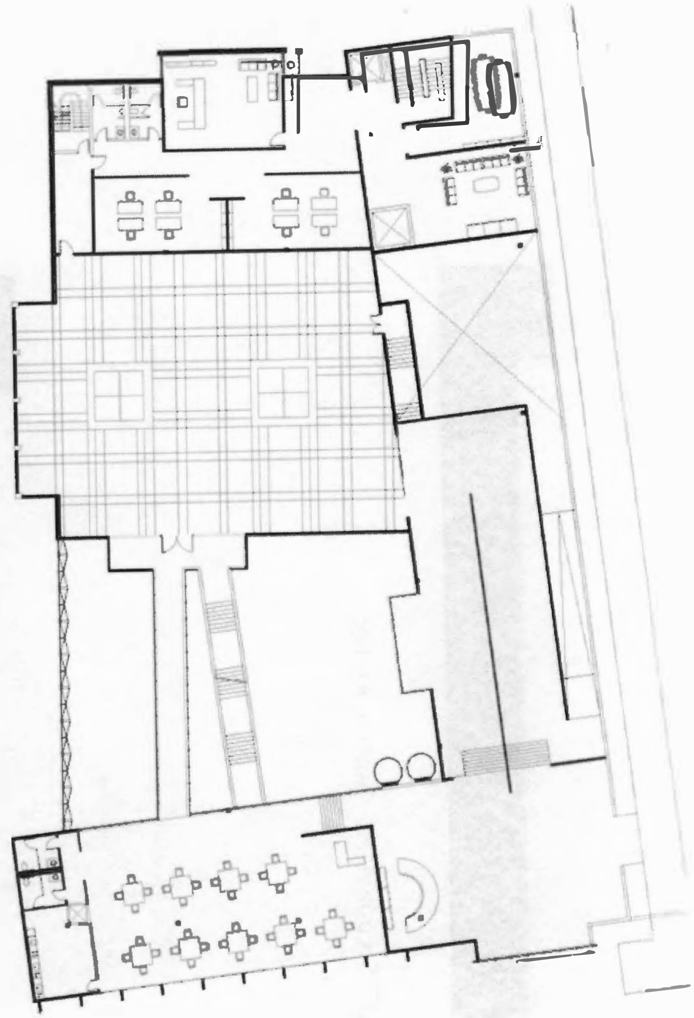

Fig73 3rd Floor Plan Source: Author

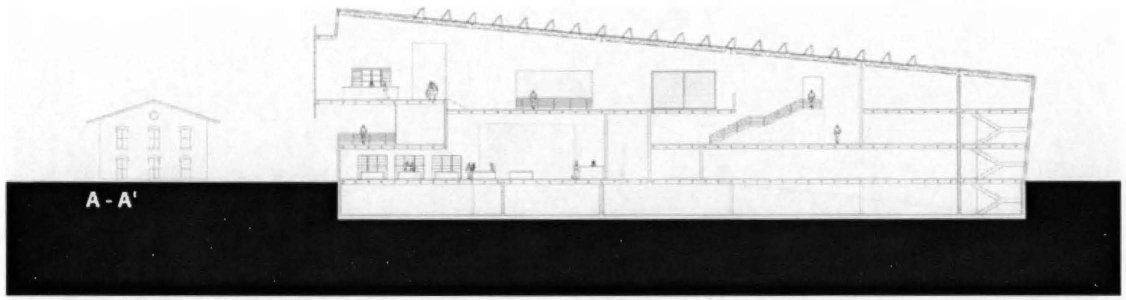

Fig77 Section A-A' Source: Author

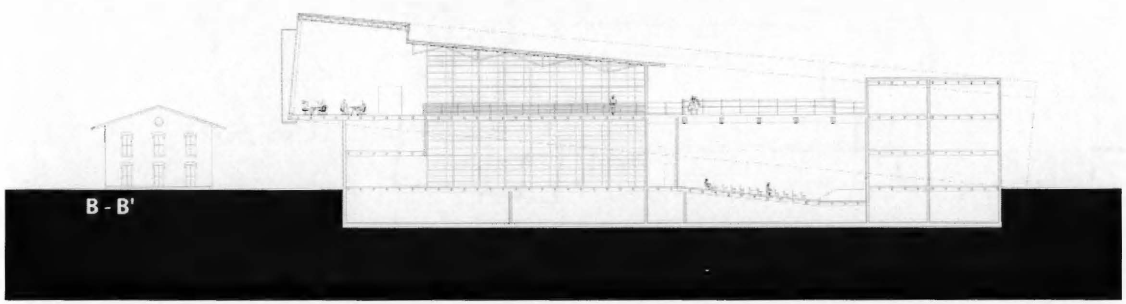

Fig78 Section B-B' Source: Author

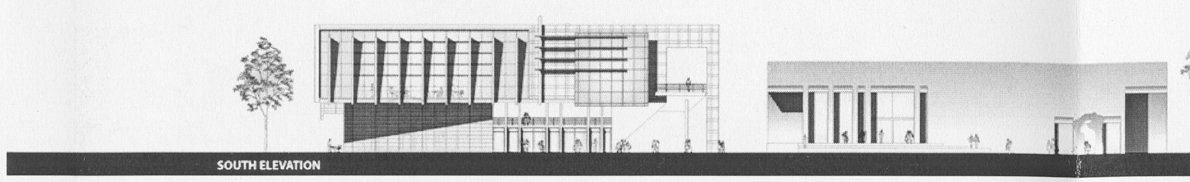

Fig74 South Elevation Source: Author

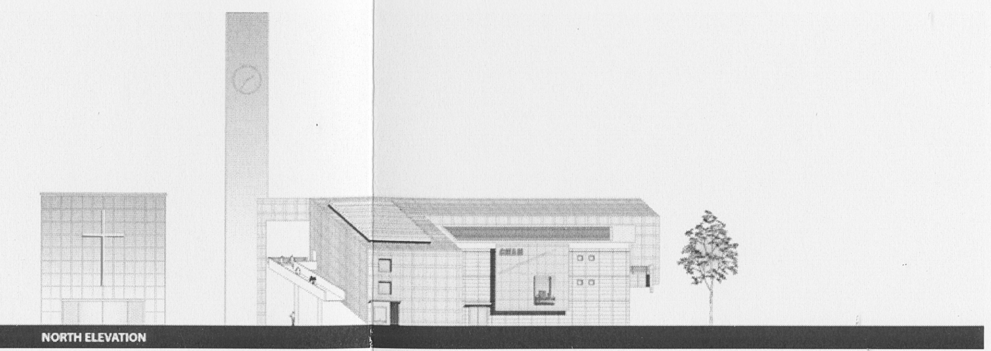

Fig75 North Elevation Source: Author

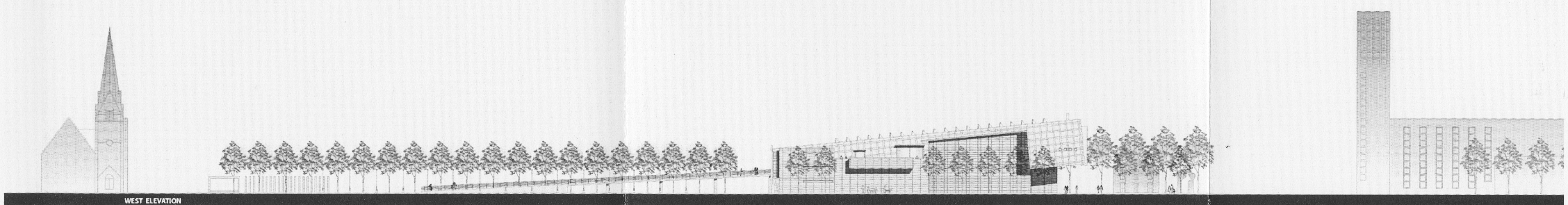

Fig76West Elevation Source: Author

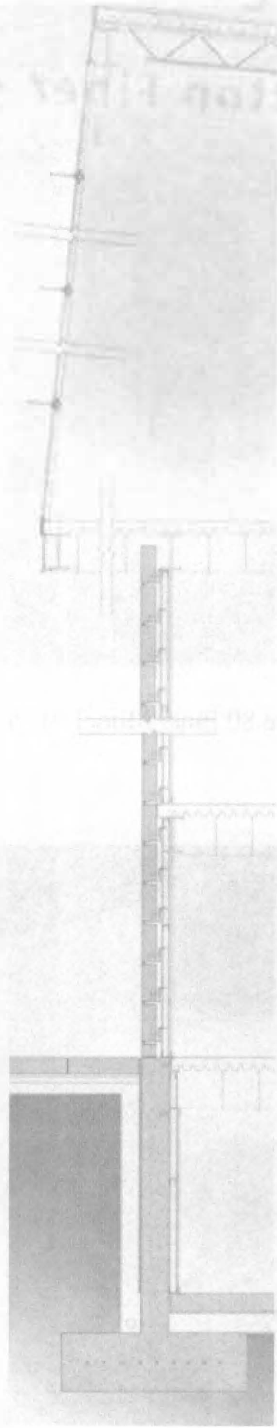

Figure 79 Wall Section Source: Author

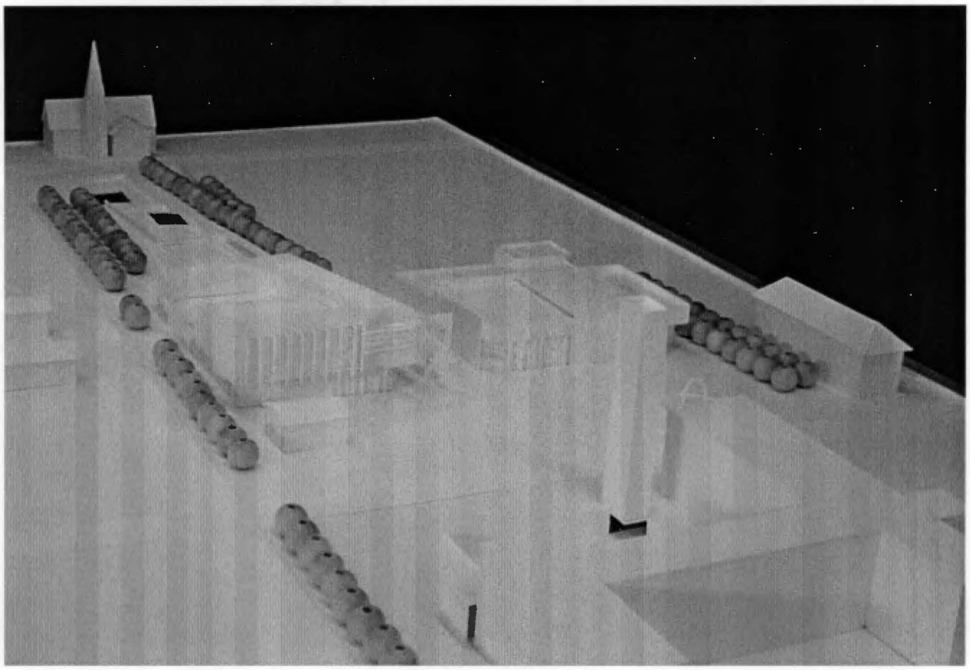

Figure 80 Final Model 01 Source: Author

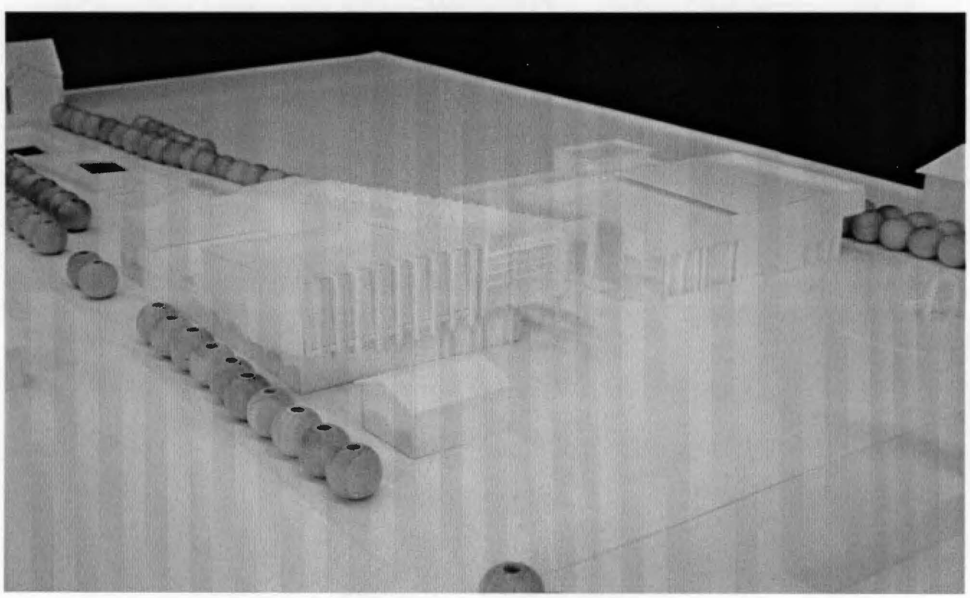

Figure 81 Final Model 02 Source: Author

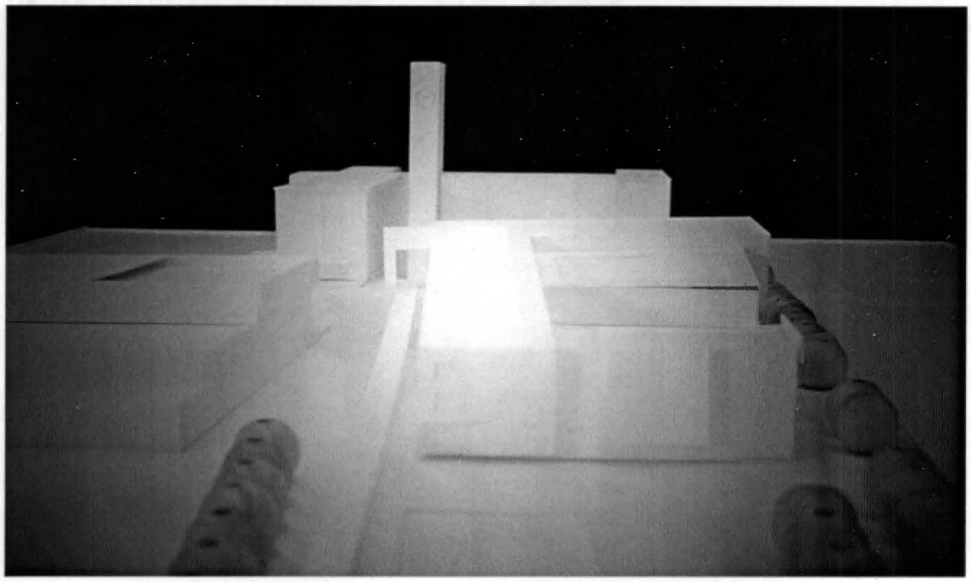

Figure 82 Final Model 03 Source: Author

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